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THE "ACME" MULTIPLE SPINDLE AUTOMATIC SCREW MACHINE*—1

DESIGN, CONSTRUCTION, OPERATION, TOOL EQUIPMENT AND ATTACHMENTS

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THE multiple spindle automatic screw machine built by the National-Acme Mfg. Co., Cleveland, was the first automatic screw machine of the multiple spindle type to prove a commercial success. It was designed and originated in the early '90's in Hartford, Conn., by Reinhold-Hackewessell and E. C. Henn. In 1901 the National-Acme Mfg. Co. was incorporated, and in 1902 moved to its present site in Cleveland. This machine was supplied with a single pulley or motor drive in 1908, in which form it will be described in this and following articles.

Principle of the Design

In principle, the "Acme" multiple spindle automatic screw machine comprises four work spindles, which are held in a cylinder and rotated by gears, the cylinder being indexed to bring these work spindles consecutively into position in front of the side-working and end-working tools. It requires one-quarter cycle of the cylinder to complete one piece, this being accomplished in the time required to perform the longest cut, which is usually a drilling, forming or box-tool turning operation. In frequent cases, it is possible to complete the piece in much less than the time required for the longest cut. Take, for instance, a long milling cut, which can be divided between the box-tools in the "first" and "second" positions. In that case, the time for the completion of the piece is considerably less than the usual time for box-turning, being slightly more than one-half. In drilling, three tools are frequently used in this manner, so that only a trifle over one-third of the time necessary for drilling the hole is required to complete the piece. The feeding of the bar takes place between the "first" and "fourth" positions, when the cylinder is indexing (on the smaller machines), and in the "first" position (on the larger machines), the stop swinging out of the way before the tools approach the work.

By referring to Fig. 1, it will be seen that there are eight standard tool positions, *viz:* Four end-working tools, two horizontal forming and cut-off slides, and two top slides working in the "second" and "third" positions. With this arrangement, it is possible to have two tools working on each of the four bars at one time—obviously, from a production standpoint, a great advantage over the single spindle type of automatic screw machine. The idle or non-productive movements in this machine are: withdrawing the tools, and indexing the cylinder carrying the work spindles; these movements occur at the completion of each piece.

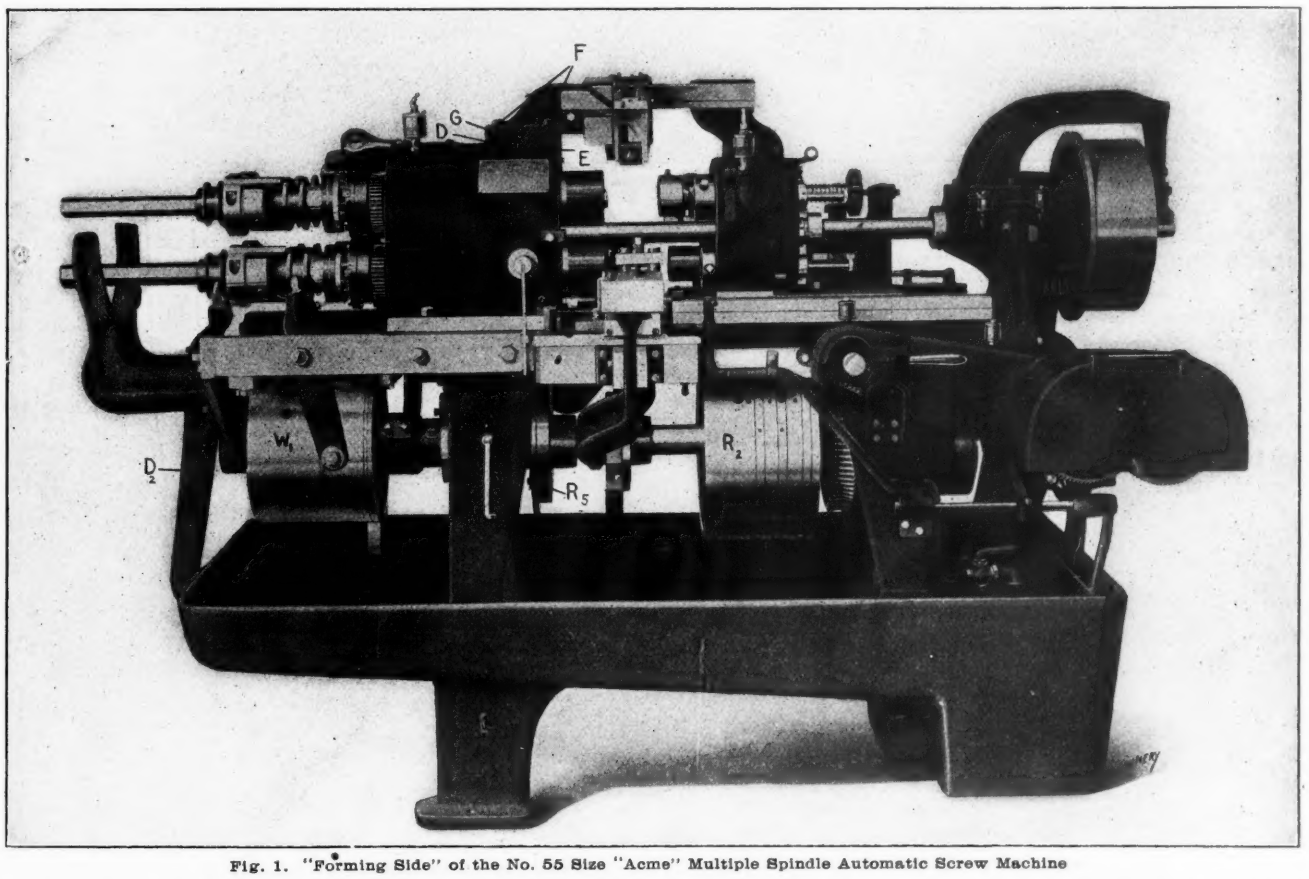

Fig. 1. "Forming Side" of the No. 55 Size "Acme" Multiple Spindle Automatic Screw Machine

Cylinder and Casing

The cylinder *A*, Fig. 3, which is carried in the head of the machine, is made from a gray iron casting, ground to standard size, and is enclosed in a casing *B* that is bolted to the frame of the machine. This casing is ground internally and is split, as shown at *C*, to provide for wear. Adjustment for wear is controlled by screws *D* and *E*, Fig. 1. The casing is contracted by loosening the screws *F* in the top bracket *G;* then turning the screw *D* to the left, screw *E* to the right, and when the proper adjustment is obtained, again turning screw *D* to the right. To expand the casing turn screw *E* to the left, screw *D* to the right, and then turn screw *E* to the right.

The cylinder *A* is held lengthwise in the casing *B* by the

* For articles on screw machine work previously published in MACHINERY see "Magazine Attachments," March, 1912, and accompanying references at end of article.

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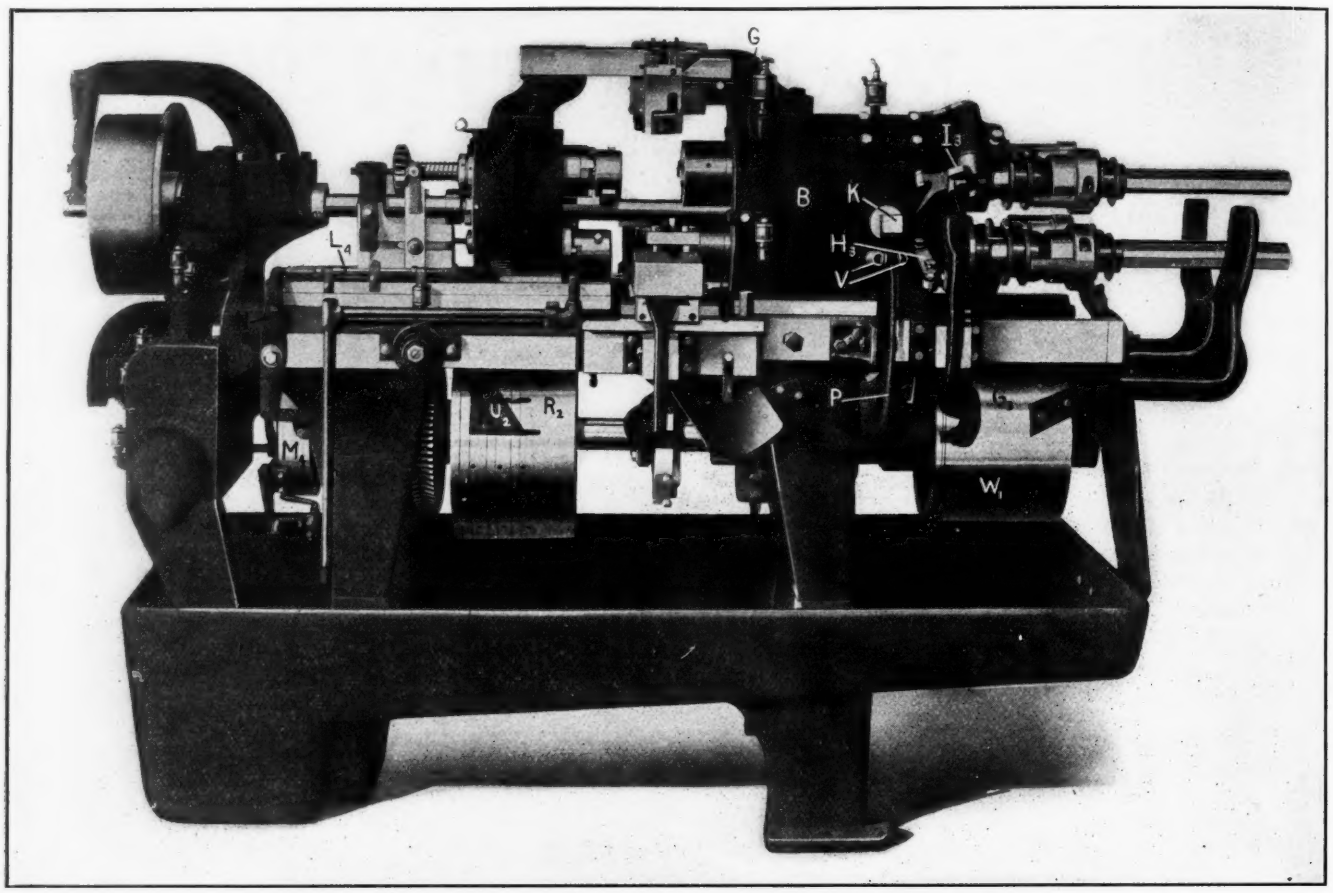

Fig. 2. "Cut-off" Side of the "Acme" Multiple Spindle Automatic Screw Machine

flange *H*, Fig. 3. The indexing of the cylinder is accomp'ished by a fan-gear *J*, Figs. 4 and 5, which meshes with teeth cut in the back of the cylinder at *I*. This fan-gear is held on a cam-shaft *M*, which makes four revolutions to one complete cycle of the cylinder. When the cylinder is indexed by the fan-gear, it is forced into the correct position by the bevel-end bolt *K*, which seats on a hardened beveled stud *L*, located in the cylinder; and when in proper alignment, the screw *N* is seated upon the flattened portion of the bolt *O*. The bolt *K* is withdrawn by an arm *P* fulcrumed at a point *Q*, and operated by a dog *R* held on the cam-shaft. This dog should engage fully with the shoe-end of the arm, before the first tooth of the fan-gear comes in contact with the cylinder, and should drop onto the dog *T* in the first step *U*, just as the adjustable tooth *S* begins to withdraw from the last tooth in the cylinder.

In operation, as the bolt *K* is withdrawn by arm *P* and dog

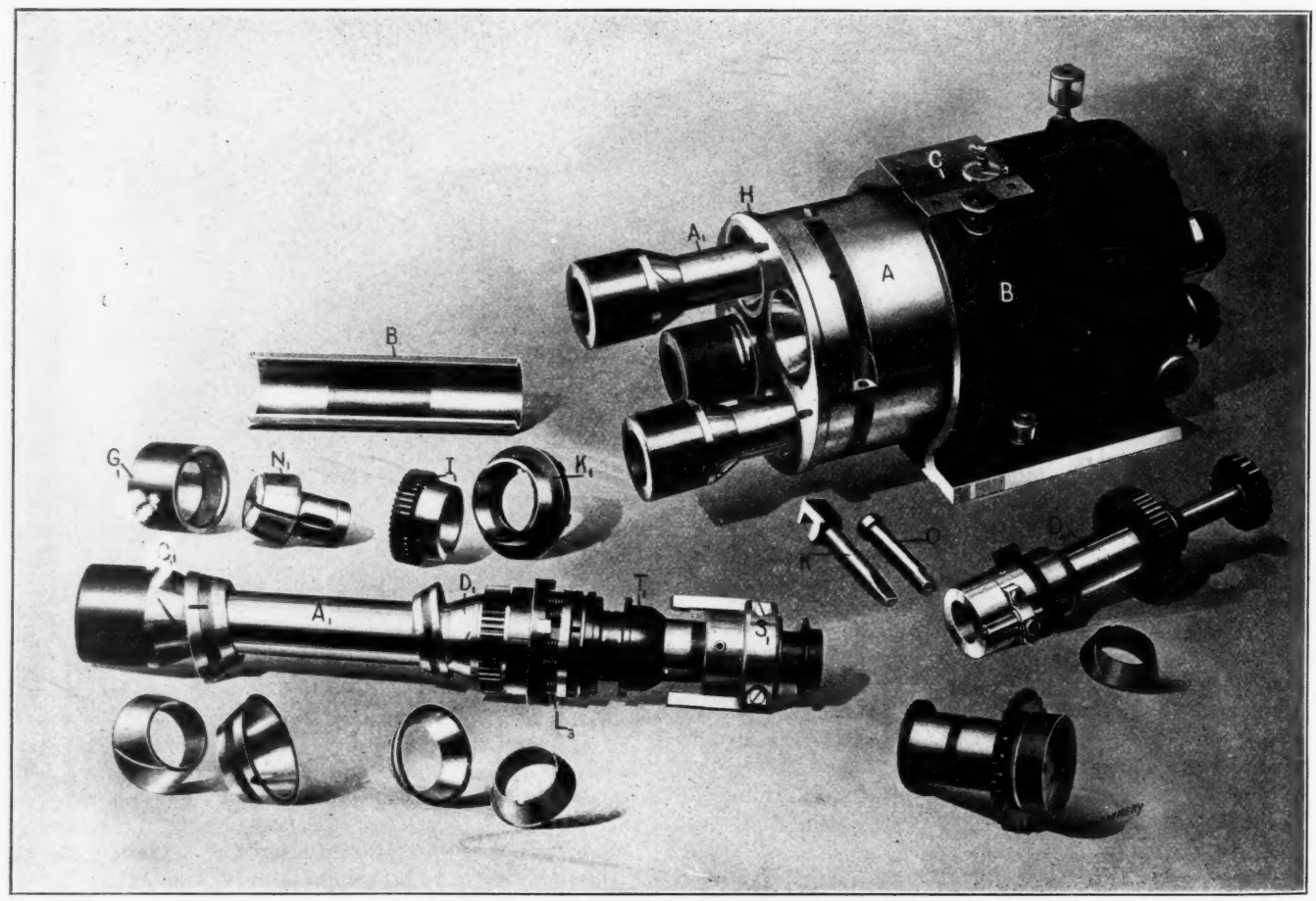

Fig. 3. The Head, Cylinder and Work-spindles partly dismantled

R, the first tooth in the fan-gear J comes in contact with the cylinder, rotating it and at the same time forcing back the bolt O. Then as the cylinder revolves around to the next position, the bolt O is forced into the cavity in front of the aligning screw N by a coil spring, the adjustable tooth S on the fan-gear having swung the cylinder around so that the aligning screw passes the top face of the bolt O. Then as the arm P drops off the dog T, the bolt K is forced "home" by the coil springs V, drawing the cylinder back and seating the aligning screw N on the flattened portion of the bolt O.

Machines leave the factory with these adjustments properly made, but after being in operation for some time, they limber up so that re-adjustment may sometimes be necessary, especially on the smaller machines, where allowance must be made for setting the dogs for extreme speed. The screw N is the only part made adjustable, so that after the machines have been in constant use and require overhauling, it is possible

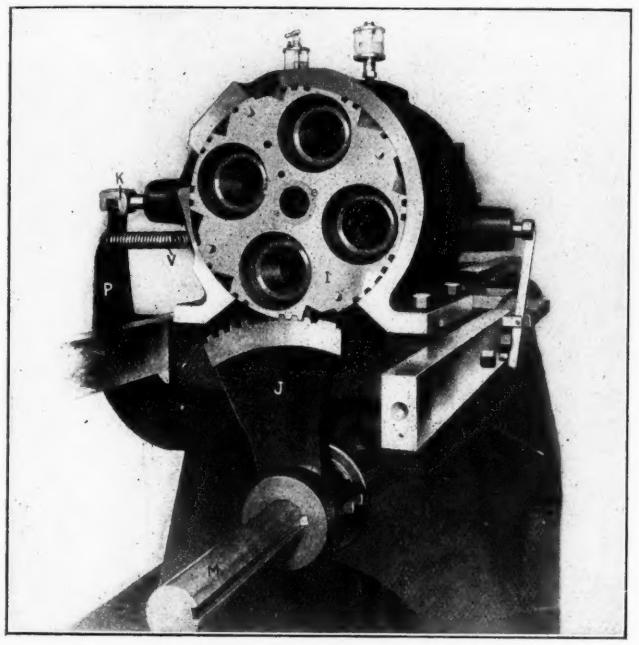

Fig. 4. View showing the Fan-gear in the Act of Indexing the Cylinder

to preserve the alignment of the work spindles with the tool spindles by simply adjusting this screw. The only parts which require adjusting, after the machine has run for some time, are the dogs R and T and the tooth S on the fan-gear, which should be set to operate at the proper time. The order in which these should operate has previously been described.

Work Spindles

The work spindles A_1, one of which is shown removed from the cylinder in Fig. 3, are made from hardened and ground steel. These spindles run in phosphor-bronze parallel bearings B_1, which are forced into the holes in the cylinder under pressure, and are prevented from turning by brass screws set through from the outside of the cylinder. These bearings are accurately reamed after insertion. The front and rear tapered bearings C_1 and D_1 are also made from phosphor-bronze, and are run in hardened and ground tapered steel bushings inserted in the cylinder. The front ends of the spindles are provided with shoulders, and are threaded (right-handed) for the reception of the caps G_1 that are internally tapered to suit the push-type of chucks used for holding the bars.

The spindles are driven by spur gears from the central shaft. These gears I_1 are free to rotate on the bronze bushings, and are provided with tapered projections or shoulders which form the internal member of a friction driving clutch. The other member of this driving clutch consists of a cup K_1, which is keyed to a sleeve that, in turn, is keyed to the spindle. The cup is held in engagement with the friction

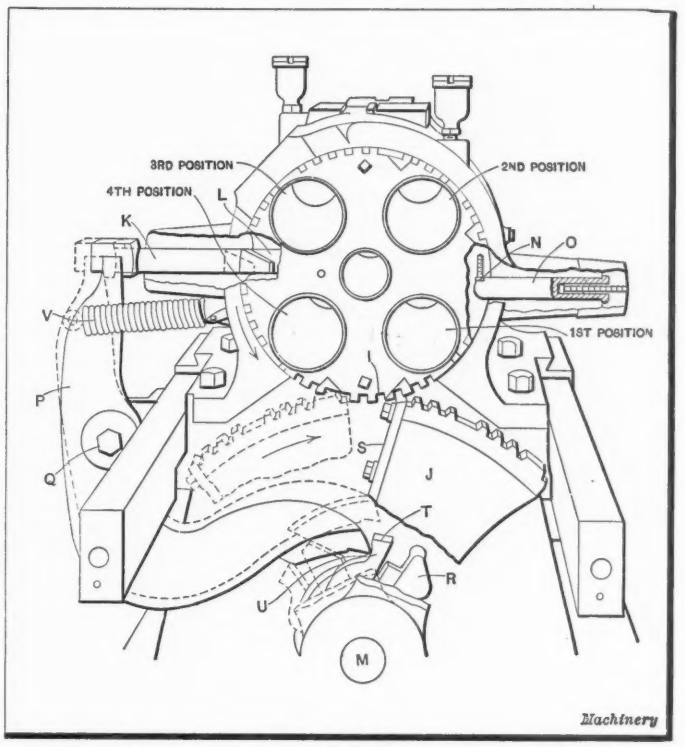

Fig. 5. View showing how the Cylinder is indexed and locked in Position

gear I_1 by coil springs L_2. The operation of this friction clutch will be described in connection with the threading mechanism.

The spindles are adjusted for end play by means of adjusting nuts M_1, Fig. 6, which are separated by a bronze washer Z_2 and screwed onto a split nut Z_3 held on the spindle. Care should be exercised in adjusting these nuts to see that they do not bind the spindles too tightly to prevent their free operation. There should be no perceptible shake in the bearings, but the spindles should turn free enough by hand so that the "back lash" of the gears can be felt. It will be seen, upon reference to Fig. 6, that as the split nut Z_3 is moved to the

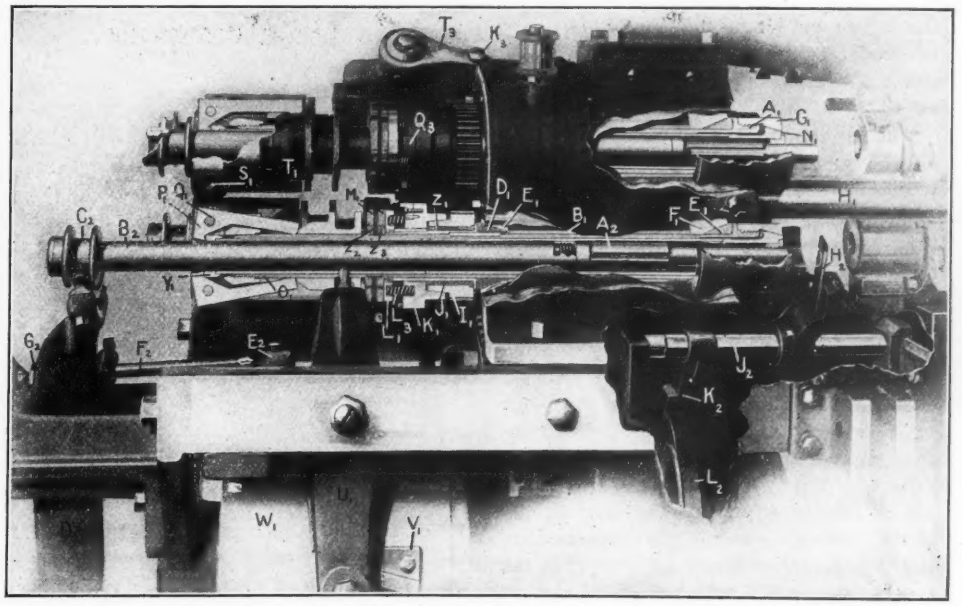

Fig. 6. Part Section of Head and Cylinder, showing Construction and Operation of the Work-spindles

right it forces the sleeve Z_1 inward. Then, as this sleeve bears against the bronze tapered bushing D_1, it is evident that the spindle must be drawn in, and, as it is provided with a collar on its outer end, it carries the other bronze bushing E_1 with it, thus compensating for end play and providing for a smooth action of the machine.

Chuck Closing, Stock Feeding and Gaging Mechanism

The spring chucks N_1, which are of the push-type, are closed in on the bars by being forced into the caps G_1, by means of the steel sleeves O_1 and fingers P_1. These fingers are fulcrumed on pins Q_1 located in collars S_1, and opened by tapered collars T_1 operated by lever U_1 and cam block V_1 held on drum W_1. The short ends of the fingers bear against hardened caps Y_1,

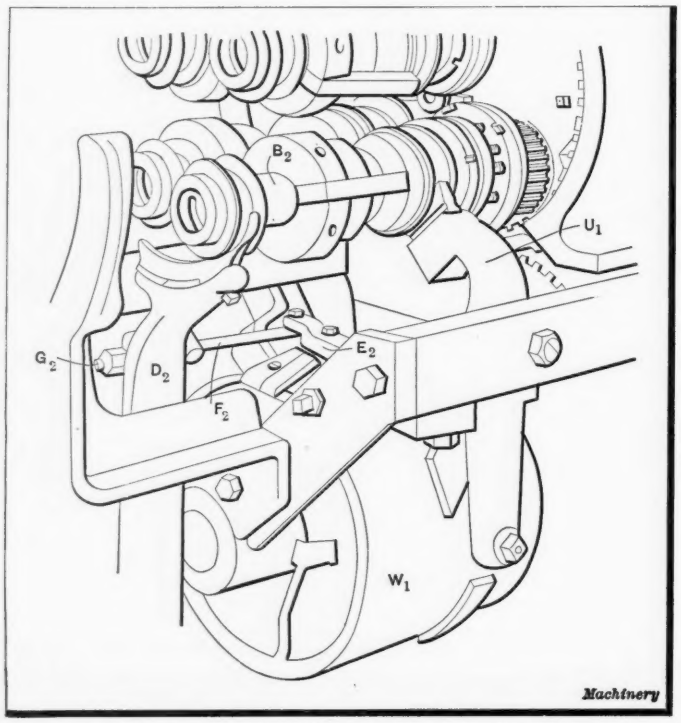

Fig. 7. View showing Operation of the Stock Feeding Mechanism

which are spun onto the rear ends of the chuck-closing sleeves O_1.

To tighten the spring chucks on the bars, the hollow set-screws in the collars S_1 should first be unscrewed and then the collars are turned to the right. As these collars are screwed onto the ends of the spindles, the fulcrum point of the levers is changed, allowing the short ends of the levers to force the sleeves further forward in closing the chucks. The fingers P_1 always travel up the full incline of the tapered collar T_1 and onto the flat portion for a lock. After the proper tension has been obtained, the hollow set-screws in the collars S_1 should be moderately tightened to force the brass shoes beneath them tightly into the threads on the spindles.

The feeding of the stock is accomplished, as shown in Fig. 6, by a split and spring tempered feed finger A_2, which is screwed (right-handed) into the feed tube B_2. This tube extends from the rear end of the spindle, and is provided with a collar C_2 in which a shoe is fitted, that is held to the upper end of the lever D_2. This lever, as shown in Fig. 1, is hinged to a bracket fastened to the base of the machine.

Movement is transmitted to the lever D_2 by a cam block held on the drum W_1, through positive feed lever E_2 and rod F_2. (See also Fig. 7.) The length of the feed is controlled by adjusting the stop G_2 on the rod F_2, which regulates the distance that the rod F_2 travels through the lever D_2 before moving it. When the cylinder is indexing from the "first" to the "fourth" positions (on the Nos. 51 and 52 machines) and when in the "first" position (on the larger machines), the lever D_2 withdraws the feed tube B_2, causing the feed finger A_2, Fig. 6, to slip over the bar, which is held tightly in the spring chuck N_1.

Cam lever U_1 now withdraws the collar T_1 from contact with the fingers P_1, thus allowing the latter to drop down into the position shown in Fig. 6. At this instant, the spring tension confined in the chuck N_1 causes it to fly back, expanding and releasing its grip on the rod and allowing the latter to be fed out. The lever E_2 is now acted upon by a cam on drum W_1 which, through the medium of the lever E_2, rod F_2 and lever D_2, propels the feed tube B_2 forward. Then by means of the spring tension on the bar, the feed finger A_2 forces the latter through the chuck until it comes in contact with the gage stop H_2.

Just before the lever D_2 has reached the forward end of its stroke, and after the bar has come in contact with the stop, the cam-lever U_1 brings the collar T_1 in contact with the fingers P_1, spreading them apart. The resulting action on the short ends of the fingers forces the sleeve O_1 against the end of the chuck N_1, which is pressed into the tapered cap G_1 and thus made to grip the bar.

The stop H_2 is fastened to a holder which can be adjusted along the hexagon rod J_2, the latter being retained in the brackets shown in Fig. 6. Located on the hexagon rod is a dog K_2, which is operated by a cam L_2 to bring the stop into and out of operation, on the Nos. 53 and 56 machines. This stop, which is off-set towards the spindles, does not occupy one of the eight tool positions, and on the smaller machines it acts when the cylinder is indexing. On the larger machines, the stop H_2 can be reversed on the holder to accommodate long work. The accuracy of the blank, for length, depends on the correct adjustment of the stop in relation to the cut-off tool, except, of course, when the end-working tools are used for facing the work.

End-working Tool Slide

The main tool slide M_2, shown in Fig. 8, carries the end-working tools—otherwise known as the turret tools—to and from the work. There are four tool spindles, to correspond with the four work spindles, held in the revolving cylinder. To make clear the following description, these will now be named in the order of their working positions. Spindle N_2 is called the "first" position, O_2 the "second," P_2 the "third" and Q_2 the "fourth" position. The uses of these various tool positions, or in other words, the operations performed from them will be explained later.

As shown in Fig. 9, the main tool slide M_2 is moved to and from the work by cam blocks held on the drum R_2. These

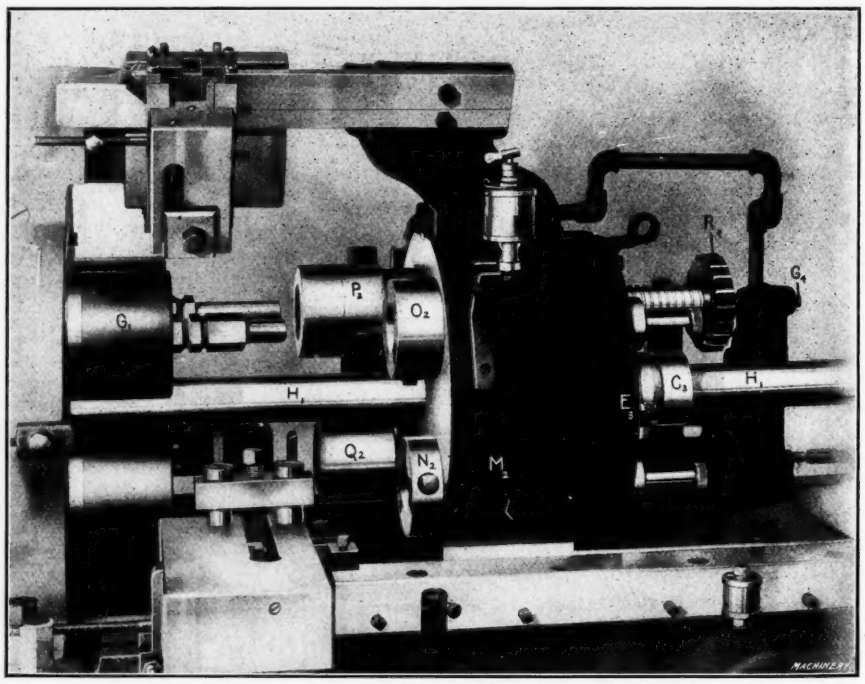

Fig. 8. Main Tool-slide and End-working Tool-holding Spindles

cams move the tool slide through the medium of the roll S_2, which is held to an adjustable roll holder T_2 bolted to the lower face of the tool slide. It is good practice to have the shanks of the end-working tools extend as far as possible into the tool spindles. This insures that they will be held more rigidly, and facilitates the production of better work. To make this possible, two methods of adjustment are provided, to be used in changing over from short to long work and *vice versa*.

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First, by changing the position of the lead cam U_2 on the drum R_2 (see Fig. 2), and second, by changing the position of the roll holder T_2. This subject will be dealt with more fully in the description pertaining to the operation of the machine.

End-working Tool Spindles

The tool spindles N_2 and Q_2, Fig. 8, are held stationary in the main tool slide, while the spindles O_2 and P_2 can be revolved. The tool spindle O_2 is revolved when it is necessary to drill a small hole in a comparatively large piece of work; otherwise it would be necessary to increase the speed of the work spindle sufficiently to give the small drill a speed high enough to give the best results. This tool spindle

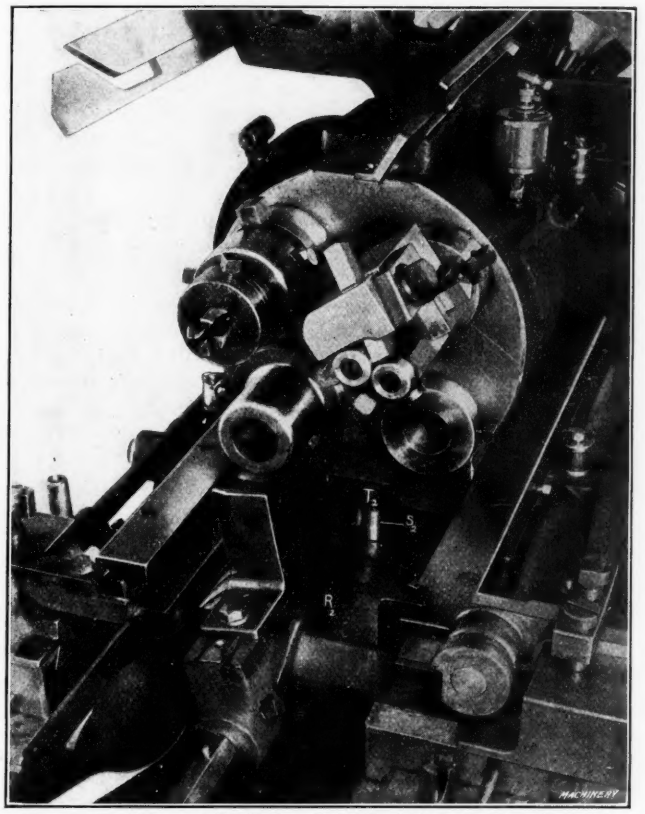


Fig. 9. End View of the End-working Tool-slide, showing how it is advanced to bring the Tools in Contact with the Work

is also used for holding a threading tool when the character of the operations on the work demand it.

The method of holding the end-working tool spindles N_2 and O_2 in the tool head is shown in Fig. 10. The rear ends of the tool spindles are reduced in diameter and threaded, and nuts V_2 and W_2 screwed onto these ends hold the spindles in the head. The end-working tools are retained in the spindles by set-screws, and are adjusted longitudinally by the

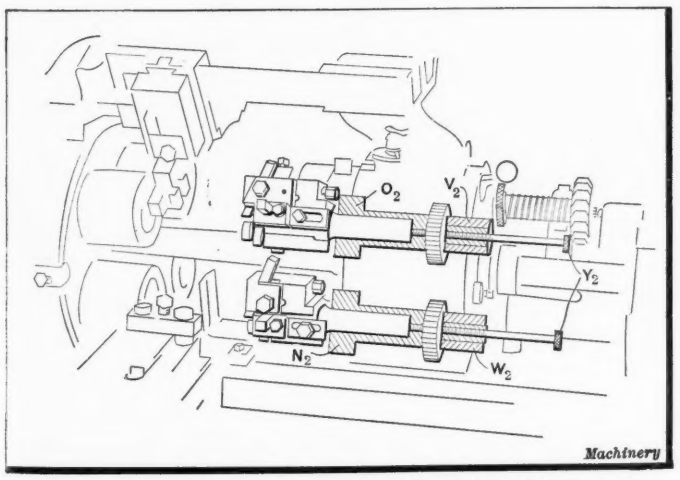


Fig. 10. Construction of the End-working Tool-holding Spindles and Method of Adjusting the End-working Tools

knurled thumb-screws Y_2. These thumb-screws also serve as gage stops for setting the tools, after they have been removed for grinding, etc. That is, the tool which has been ground is returned to the same relative position in the holder. When the end-working tool is held in the tool spindle in the position corresponding to the one where the cut-off tool is being used, it is necessary to use a shorter cam. The take-back cam for the end-working tool slide should also be set forward. This

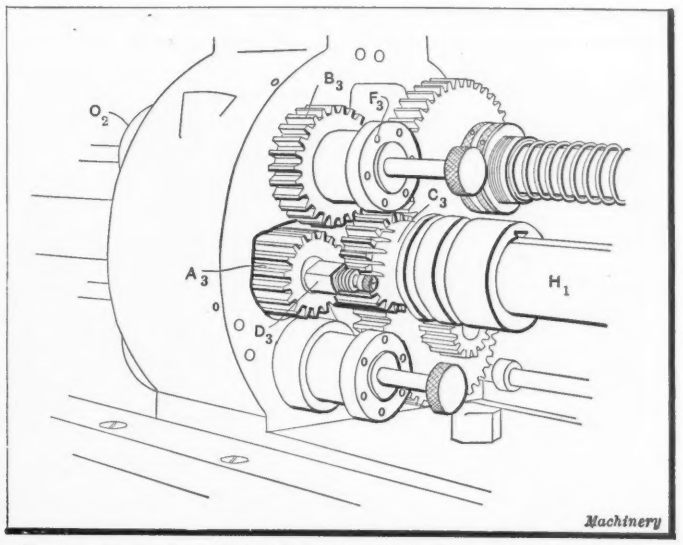


Fig. 11. View of the Tool-slide with Back-plate removed, showing how the Spindle in the "Second" Position is rotated

is done to allow the tool to clear the work before the piece is cut off.

When it is desired to use the tool spindle O_2, Fig. 11, for revolving a drill or other tool, it can be rotated by gears A_3 and B_3 which are driven by the sliding gear C_3 keyed to the

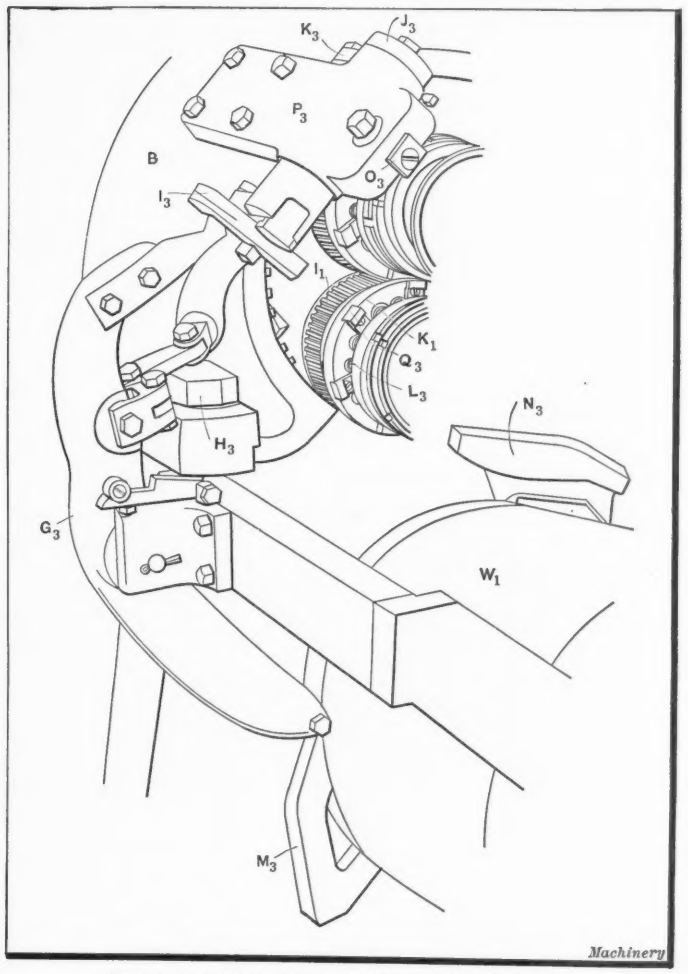


Fig. 12. Spindle Locking and Disengaging Mechanism

driving shaft H_1. The intermediate gear A_3 is carried on a stud D_3, which is located in the back plate, removed in Fig. 11. To drive this spindle, loosen the set-screw and the nut F_3 to allow the spindle to rotate freely. Then unscrew the nut on the intermediate stud D_3, moving the latter to bring the intermediate gear into mesh with the sliding gear C_3. Now clamp the stud D_3 by screwing the nut up tightly.

Threading Mechanism

The method of cutting a right-hand thread in the "Acme" multiple spindle automatic screw machine is to stop the rotation of the work spindle when in the "third" position, and hold it rigidly while the thread is being cut with a die or tap held in the tool spindle P_2. This provides for the use of a proper speed for the threading tool, regardless of the speed

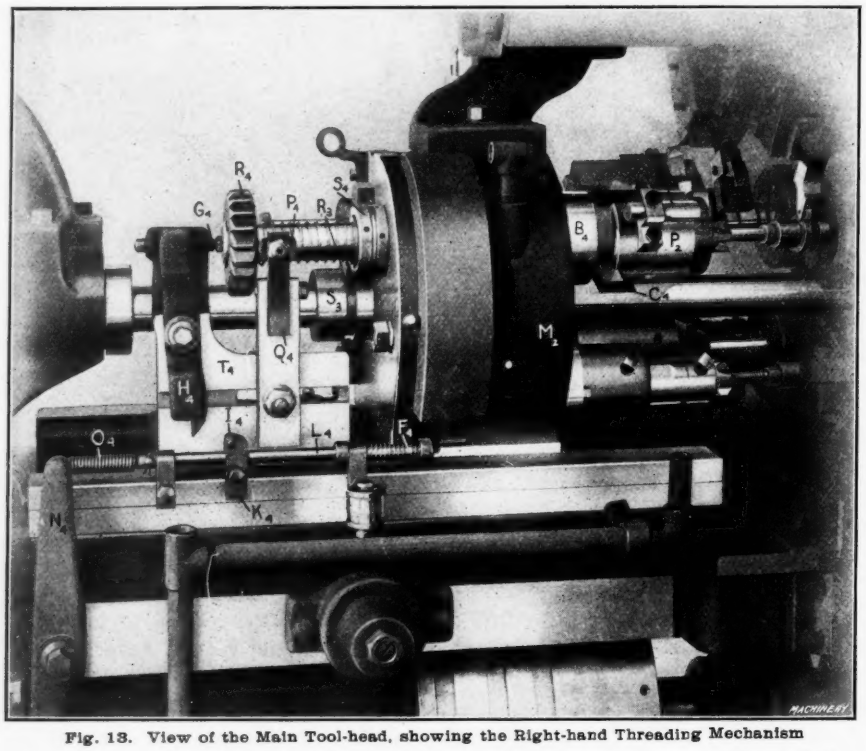


Fig. 13. View of the Main Tool-head, showing the Right-hand Threading Mechanism

at which the other tools are working—producing a better thread and not taking any extra time to do so—a feature peculiar to the "Acme" multiple spindle automatic screw machine.

This is accomplished as shown in Figs. 2, 6, 12 and 13, where different views of the same parts are represented by the same reference letters. The work spindles are stopped, one at a time, as the cylinder indexes them to the "third" position, when the gear I_1 and cup K_1 are disconnected. This action is controlled by a cam M_3 on the drum W_1, operating through the lever G_3 and the special locking device H_3. This device, in turn, operates the levers I_3 and J_3 bringing the roller K_3 into contact with the cup K_1, thus compressing the coil springs L_3 and separating the cup from the gear. The

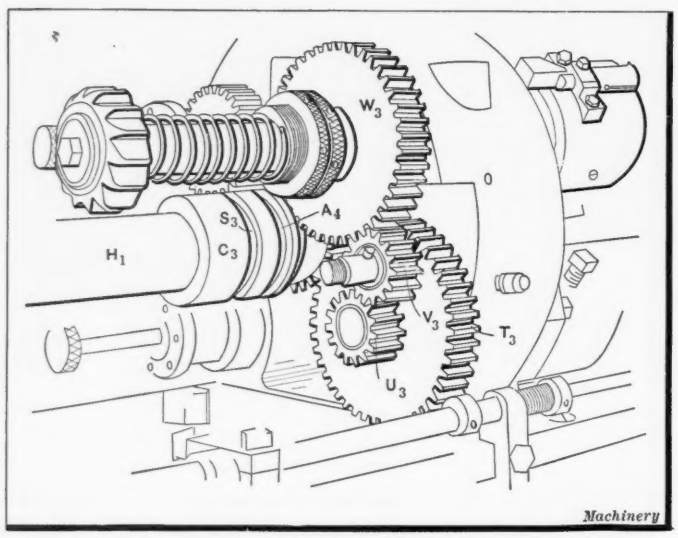


Fig. 14. Gears arranged to drive the Right-hand Threading Mechanism at its Slowest Speed

opening or friction disengaging cam M_3 is positive, while the closing or friction engaging cam N_3 is adjustable on the drum W_1.

The length of time that the work spindle must be held stationary in the "third" position is determined by the duration of the threading or other special operation performed from this position. To hold the spindle rigidly in this position, the adjustable plunger in the block O_3 (located on the under side of the bracket P_3 which is bolted to the casing B) is brought in contact with the lugs Q_3. These lugs are inserted in the cup K_1, and overlap the plunger in the block O_3 about ⅛ inch when the springs L_3 are compressed. These springs may require replacing after continuous use, but usually a thorough cleansing of the gears I_1 and cups K_1 with kerosene, to let them come close together, will prove effective in holding these parts in contact.

Now that the method of stopping the rotation of the work spindles preparatory to threading has been described, the next step is to explain how the threading spindle is rotated. This is accomplished by the sliding gear C_3 keyed to the shaft H_1; this gear drives the spindle in a right-hand direction, through a train of gears as shown in Figs. 14 and 15, giving two speeds to the threading spindle for each speed of the work spindles.

When the shoe R_3, see Fig. 13, is in the groove S_3 of the sliding gear, the drive is transmitted from the sliding gear through the gears T_3, U_3 and V_3 to the gear W_3 on the threading spindle, as shown in Fig. 14, rotating the latter at its slowest speed. When the shoe R_3 is in the groove A_4 in the sliding gear, the drive is direct from this gear to the gear W_3, as shown in Fig. 15, rotating the threading spindle at its highest speed.

In threading brass, or cutting very fine threads on soft steel, the highest speed may be used. It is generally advisable to run the threading spindle at its slowest speed, that is, through the compound gears, as shown in Fig. 14. When it is desired to prevent the threading spindle from rotating, the

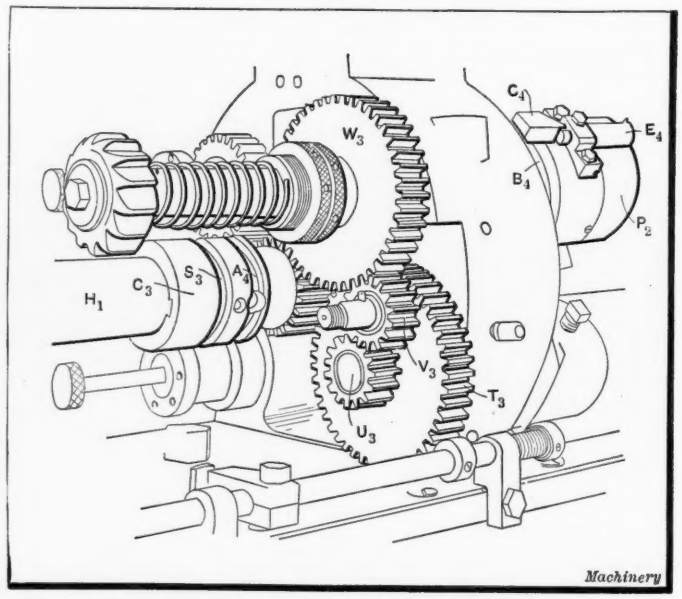


Fig. 15. Gears arranged to drive the Right-hand Threading Mechanism at its Fastest Speed

shoe R_3 is drawn up, and the gear C_3 slid along the shaft H_1 out of contact with the other gears. As shown in Fig. 13, the threading spindle P_2 is driven by a block C_4 attached to the holder B_4. This block engages with an adjustable pin E_4 attached to the threading spindle P_2. The pin E_4 is adjusted out when the forward travel of the threading tool must be faster than the speed at which the main tool slide is traveling.

Now as the main tool slide does not always travel at a speed equal to the lead of the threading tool, it is necessary, especially when the threaded portion is short or the thread is of a fine pitch, to provide some means of giving the threading tool a proper start, so that it will "lead" onto the work without

being forced. The device used for this purpose is shown in Fig. 13, and consists of a plunger G_4, and auxiliary mechanism, which is operated just as the threading tool approaches the work. This plunger G_4 is operated by a swinging pawl H_4, which is given an impulse at the proper moment by a roll I_4 held in the block K_4, the latter being adjustable on the rod L_4; this rod, in turn, is operated by a cam on the drum M_4, see Fig. 2 (with the exception of machines Nos. 51 and 52, where the cam is on the drum R_2), through the lever N_4 and cushion spring O_4, the latter breaking the mechanical action of the starter, and allowing the threading tool to follow the pitch of the thread. This makes the starting of the threading tool positive, and the operation of the mechanism flexible. The spring F_4 returns the rod L_4 to its "back" position.

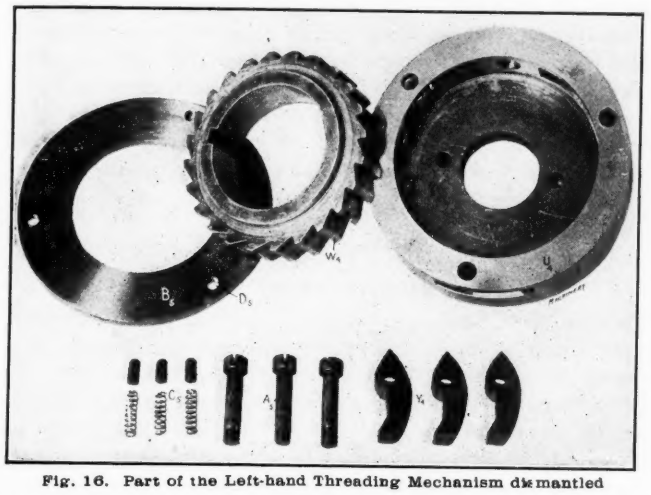


Fig. 16. Part of the Left-hand Threading Mechanism dismantled

After the starting mechanism operates in the manner described, the threading tool "leads" onto the work to the required distance. When it reaches this point, the main tool slide drops back, but the threading spindle P_2 is prevented from doing so, because of the grip of the threading tool on the work, thus compressing the coil spring P_4. When the tool slide drops back disengaging the driving pins, flexible pawl Q_4 (the holder retaining it being adjustable on the bracket T_4) comes in contact with the ratchet R_4 on the rear end of the threading spindle, preventing the latter from rotating, when the work spindle is rotated in the manner previously described, to run the threading tool off the work.

Now as the work spindles revolve in a left-hand direction, the threading tool, being right-handed, is run off the work when the spindles are revolved. Then spring P_4, which has been compressed by the tool slide dropping back, returns the threading spindle to its normal position, after the threading tool leaves the work. The adjusting nuts S_4 are used to take up the end play in the threading spindle holder, which is shown dismantled from the tool head at D_4 in Fig. 3.

To cut a left-hand thread, it is necessary to change the device shown in Fig. 13. To do this the nuts S_4 are removed, and are replaced by a special collar U_4, Fig. 16. A special washer V_4 also takes the place of the ratchet R_4 on the end of the threading spindle, as shown in Fig. 17; this illustration shows the left-hand threading mechanism assembled in the tool head.

Fig. 16 shows the principal parts of this left-hand threading device. Here, U_4 is the collar which screws onto the threading spindle; W_4 is the ratchet (keyed to the threading spindle), which in conjunction with the pawls Y_4, screws A_5, plungers and springs C_5, prevents the threading spindle from revolving independently of the driving pins when the thread is being cut. The washer B_5 is used to enclose the mechanism. The block C_4, Fig. 13, and the pin E_4 are also removed, and are replaced by similar blocks shown in Fig. 17, which are designed especially for left-hand threading.

The method of cutting a left-hand thread is to revolve both the threading spindle and the work spindle. The work spindle is rotated left-handed faster than the threading spindle, thus producing a relative motion between the spindles that cuts the thread by the work spindle gaining on the threading tool. The tool slide brings the threading tool up to the work, when the tool "leads" on, compressing the coil spring P_4. When the threading tool advances to the required distance, the work spindle is stopped by means of a cam on drum W_1 (Fig. 2), but the threading spindle is still revolved by the same gears that are used for rotating the spindle for right-hand threading. As the threading spindle in backing off revolves in a right-hand direction, it is evident that the pawls Y_4 will allow the ratchet W_4 to rotate with the spindle. When the threading tool leaves the work, the spring P_4 returns the threading spindle to its normal position.

* * *

REDUCING FIRE RISK IN WOODWORKING PLANTS

The great inflammability of materials and products in a woodworking plant, together with the inevitable collection of dust and sawdust liable to flash into flame from spontaneous combustion, or the careless use of matches, makes this type of property an extremely hazardous one from the fire point of view. Insurance rates of 8 per cent per annum are not at all uncommon, and a rate as high as this is justified in many of these properties.

Elimination of fire risk is of extreme importance, as it would result not only in absence of danger from fire but a very material decrease in the cost of insurance. The placing of an engine and boiler room close to the plant increases the fire risk, particularly as inflammable dust is always carried from the plant into the engine room by the heavy belt and is liable to cause an explosive fire. Electric drive does away with this inflammable dust, and if induction motors are used, also eliminates danger of sparking. The saving effected in insurance premiums alone is sometimes sufficient to warrant the erection and electric equipment of new fireproof buildings.

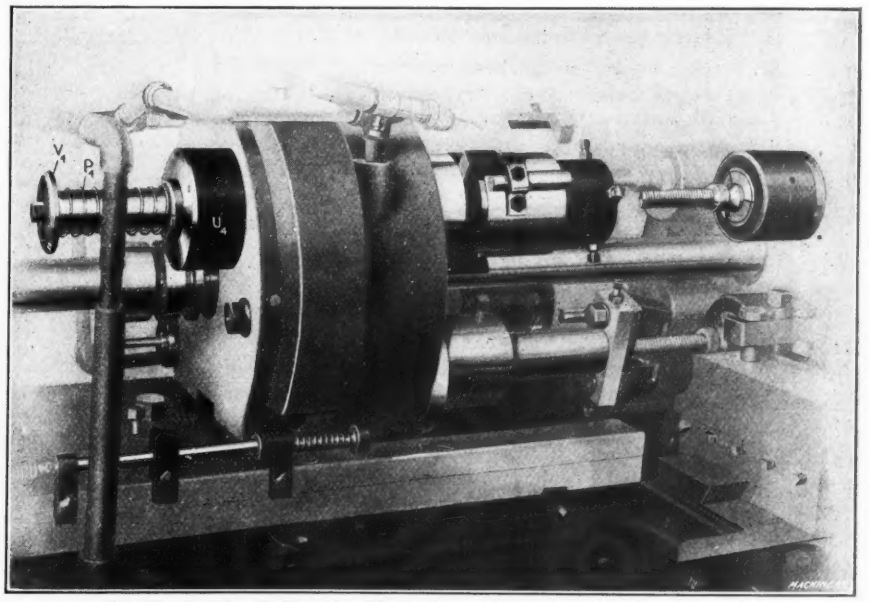


Fig. 17. Left-hand Threading Mechanism assembled in the Main Tool-slide

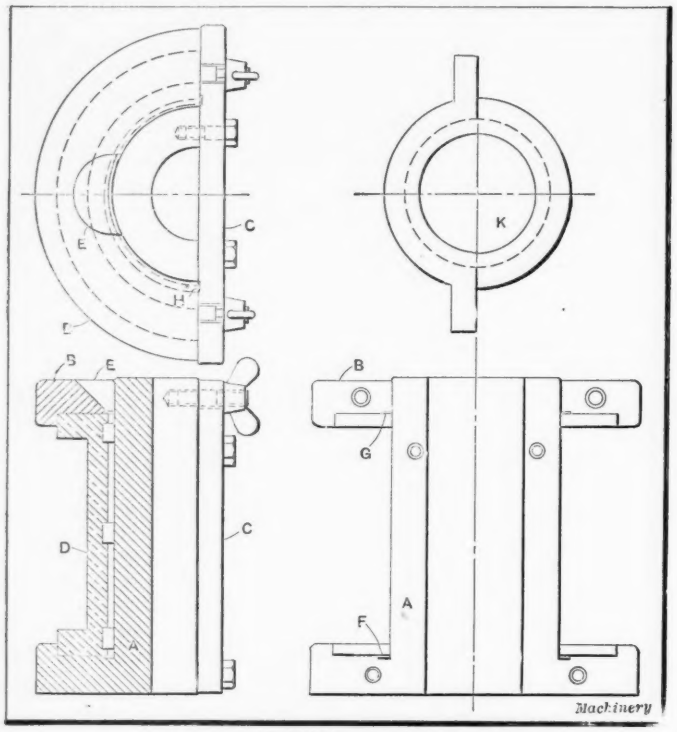
This is so, however, only if the buildings are adequately protected by a complete system of automatic sprinklers. Recent figures on the cost of cheap wooden buildings with engine drive as compared with the best fireproof construction driven electrically and protected by automatic sprinklers, show that for a certain plant the cost of the former including all machinery will represent $28,800 as against $38,300 for the latter. The difference in insurance premiums, however, amounts to more than $2000 a year in favor of the more expensive plant. It is seen that this difference is more than twenty per cent dividend upon the difference in cost, and that the additional expenditure on first cost is more than justified on every ground.

MAKING BABBITTED BEARINGS IN HALVES

BY S. THERESA

When babbitting, it is usual to retain the lining either by holes or by peripheral and longitudinal grooves which are generally undercut. The writer has found after long experience that neither holes nor undercut grooves are necessary, and that plain grooves turned when the bearings are bored are sufficient if proper precautions are taken in the preparatory tinning of the bearings. Some thousands of bearings have been made in the manner to be described without the slightest difficulty.

Before the tinning, which is a dipping process, the bearings are well cleaned by buffing and by scraping in the corners. Every trace of grease is then removed by immersing them in boiling soda water. When dry, and while still warm, the parts which are not to be tinned are painted with a mixture of oxide of iron and water. The inner surface is smeared with paste rosin, and then the bearing is dipped into a bath of solder. If the solder does not adhere to some portions, these are further cleaned and the dipping is repeated. The bearings are then allowed to cool and any solder adhering to the joint is removed by a touch on the disk grinder.



A Fixture for Babbitting Bearings in Halves

It must be understood that prior to tinning, the bearings have been turned and bored and the joints ground. To insure that the joint is exactly on the center line of the hole, the bearings are bored in a fixture similar to an angle plate, with its face exactly in line with the lathe centers. Two half bearings, one having lugs, are soldered together, as shown at *K* in the illustration. The joint faces of these lugs are bolted to the face of the angle plate. After boring and cutting the three peripheral grooves, the bearings are turned to accurate dimensions on an ordinary mandrel and afterwards split apart.

As a mold for casting the babbitt, the jig illustrated was designed. It consists of a mandrel *A*, two of which are made together by a method similar to that by which the bearings are produced. Two jigs are required when the output is large. The lower flange of the mandrel and the top locating flange *B* are recessed to the diameter of the flanges of the bearings. The upper flange, having an inlet for pouring at *E*, is clamped in the manner shown, so as to be readily put into place or removed. The brass is also prevented from moving by the back plate *C* being screwed onto the mandrel; the small grooves *F*, *G* and *H* are intended to allow some surplus babbitt at these points. It was found that the babbitt sometimes failed to run up into the sharp corners which produced a bad appearance in the finished bearing.

Prior to pouring, the jigs were slid into a small gas heating furnace, one at a time. While one half was being poured and the finished work removed, the other was heated in the furnace to a moderate temperature, not sufficient to cause any appreciable distortion in the jig. No trace of red heat was permitted. After pouring, the small projecting parts at *F*, *G* and *H* were removed on the disk grinder. About 3/32 inch on the diameter was allowed for boring after the bearings were fitted into position in, say, a lathe headstock. The bearings were then bored to the exact size of the journals, or a little smaller, but never larger, as is the practice followed by some in order to reduce the scraping. Sometimes, although not often, small blow-holes would show in the boring. These were simply soldered before scraping. Both before and after the final boring, the bearings were tested by hammer blows. Any sound of hollowness was sufficient reason for rejection. In the initial stages of the practice, there were many rejections. After the men began to realize the importance of cleanliness and care, this trouble became infrequent.

* * *

A BABBITTING DEVICE

BY C. F. MEYER*

In Fig. 1 is shown a so-called "jack-comb" used for a certain kind of textile machinery. This comb consists of a number of punched sheet-iron plates *A*, which are held together by a babbitt base *B* and a babbitt connecting strip *C*, running along the rear side of *A*. This strip also serves as a stop for the swinging pieces *D*. The latter swing around a small shaft *E* running through the entire length of the comb section. Two holes *F* are provided to fasten these sections upon a long base, one beside the other, until the desired length of the complete comb is obtained.

It is rather difficult to cast base *B* and strip *C* in such a way that all the plates are held correctly, as the latter must be exactly at right-angles to the base, and parallel to and at the same distance from each other. Each comb plate must also be held rigidly in its position. These sections are made in large quantities and must be so babbitted that no additional finishing is required; hence, a special device is used for the work. It is the purpose of this article to describe this babbitting device.

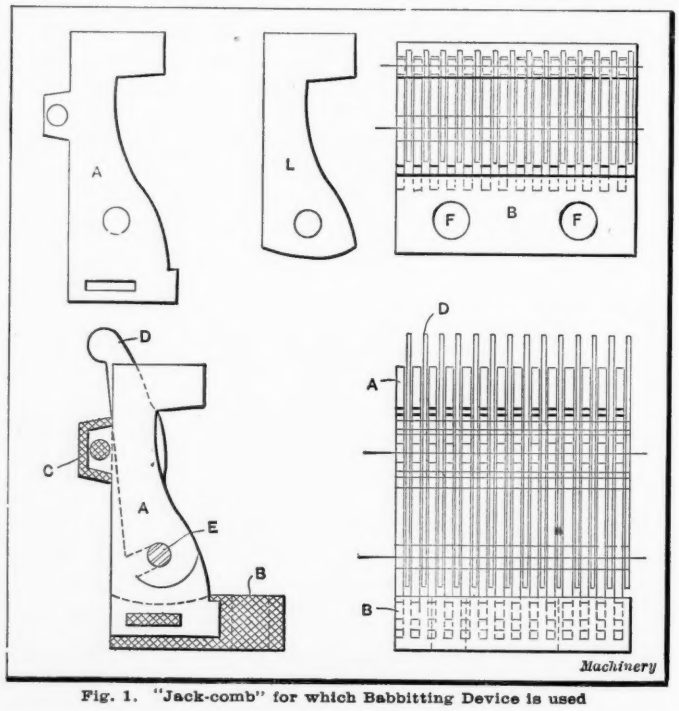


Fig. 1. "Jack-comb" for which Babbitting Device is used

As shown in Fig. 2 the device consists of a cast-iron base *X* having an extension or projection *G* cast in one piece with it. The right-hand end of extension *G* has a hinge *I* in which the eye-bolt *K* swings on a pin. The inner side of projection *G* is finished in such a way that the back sides of plates *A* fit against it when these are placed upon pin *H*. Between

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each of the plates *A* a distance piece *L* is placed, as shown in Fig. 1. This piece corresponds exactly, in shape, to piece *A*, except that it does not cover it at the base *B*, and at the rear extension *C*. When all the plates are in position, the top plate will be flush with the finished top surface of extension *G*. A swinging arm *M* then brings all the pieces into position. This swinging arm is clamped by the eye-bolt *K*. The steel part *U* fastened to the inside of arm *M* is shaped to suit the curved front part of the plates so as to force them into position. A crank is provided on the end of eye-bolt

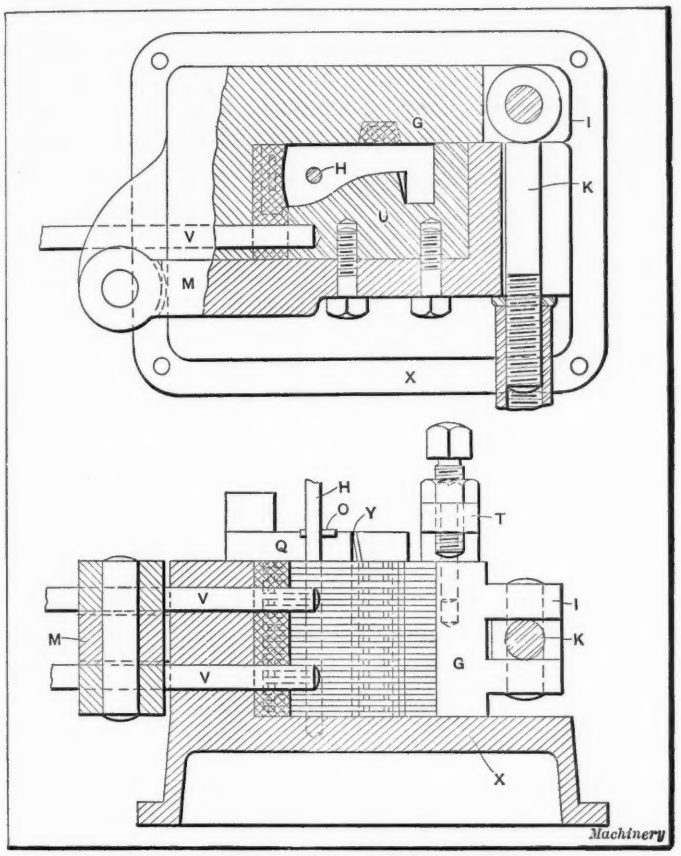


Fig. 2. Sectional Views of Babbitting Device

K, as shown in Figs. 3 and 4; hence, the operation is quicker than if a nut were used.

The rear side of extension *G* is provided with a bracket to which cover *Q* is attached. This cover is swung out of place while the plates are being inserted, and when the column of pieces is completed it is swung over the tops of the plates.

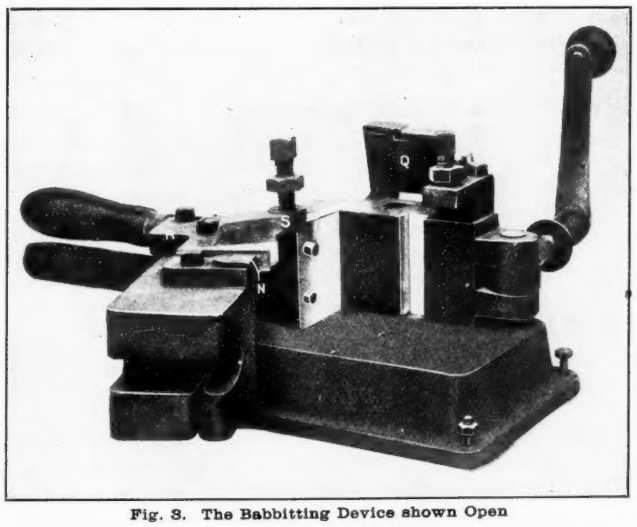


Fig. 3. The Babbitting Device shown Open

A second covering plate shown at *R*, Fig. 3, is fastened to the top of the swinging arm *M*. This plate is also provided with a projection *S* carrying a hardened set-screw which works against a small plate *O*, Fig. 2, riveted to cover *Q*, thus pressing the latter tightly against the column of punchings. Another bracket *T* is provided on casting *G*. This carries a set-screw which presses upon a second steel plate *N* fastened to swinging arm *M*. In this way, the covering plates *Q* and *R* are pressed tightly against the finished top of base *X*. At both sides of the hinge for arm *M*, Fig. 2, holes are drilled to correspond with the holes in the babbitt base *B*. Before the babbitt is poured in, two pins *V* are inserted through these holes far enough to be guided by two corresponding holes in piece *U*. These pins serve as cores for the holes in

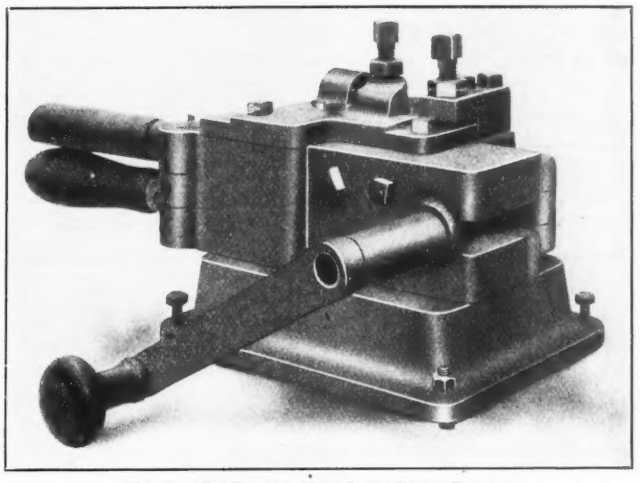


Fig. 4. The Device Closed, ready for Pouring

A and are provided with wooden handles so that they can be manipulated even though they may be heated by the babbitt.

After the device is filled with the plates and closed, the babbitt is poured through an opening at the top. The air escapes through the small opening *Y*. The results obtained by the use of this fixture are excellent, and no further finishing is necessary after the section leaves the device. Fixtures based on this principle may be found useful for similar jobs that may confront machine designers.

* * *

In a paper read before the Society of Automobile Engineers, Mr. Frank Burgess, in speaking on worm-gearing, emphasized that the hardening process, for the Hindley worm especially, should be such as to cause the least amount of distortion. The object of this is that the teeth of the Hindley type, which it is impracticable to grind, can then be lapped, making them concentric with the hole, which is very essential in a worm drive of this type. The teeth should have a mirror-like polish. In this way, with hardened concentric polished tooth surfaces, the Hindley type presents a better surface for contact than the best form of straight worm, even though the latter is finished by grinding.

The worm gear should be made of a special mixture of hard bronze. The gear should be slightly polished after being cut to insure a perfectly smooth glazed surface to mesh with the hardened polished worm. This set of gears, properly housed, with ball bearings and the right lubricant used, will give an efficiency of at least 90 to 95 per cent. A simple method of testing the gears for efficiency without elaborate apparatus is to run them in their regular housing, containing a bath of oil, subjected to the load to be transmitted. If the worm and gear do not have a high temperature after running several hours, they show a high efficiency and suitability for the given purpose.

* * *

The department of education in Prussia is considering the use of the moving picture machine in certain courses in the higher educational institutions. During last summer several large manufacturers of moving picture films were given an opportunity to show to the educational authorities films adapted to such purposes. Two fully equipped moving picture machines have been donated by a private citizen to the schools of Berlin. One of these machines is to be used in the institute corresponding to our normal schools, and the other in the high-schools of Berlin. Moving picture films are now available on anatomical, biological and bacteriological courses. Ordinary stereopticons have been used for some time in connection with the courses in geography, mineralogy, zoology and art.

THE VAUCLAIN TWIST DRILL*

Speaking generally, there can be no better definition of economical drilling than "rapid drilling"—the saving of time. The fact that a drill will cut at some phenomenal speed and consume little power in so doing means very little, so far as productive capacity is concerned. The object in view is the removal of chips. The productive possibilities of any metal

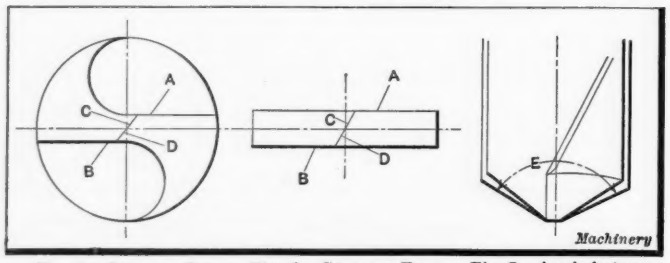
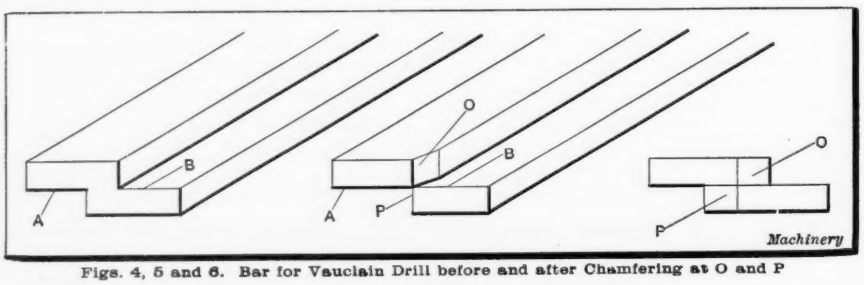


Fig. 1. Common Type of Twist Drill — Fig. 2. Common Form of Flat Drill — Fig. 3. Angle between Cutting Edges

cutting tool are limited by its stress and heat resisting capacities. The temperature at which the tool will continue to work successfully depends upon the excellence of the material from which it is made and the perfection of the process used in its manufacture. The rapidity with which heat is generated from the friction of the cut, and the stress set up in the tool, depend upon the design and the selection of feeds and speeds. Other conditions being equal, the strength of a tool depends upon the area of its cross-section and the distribution of the metal composing it.

In the case of drills, the size is necessarily limited by the size of the hole to be drilled, and the section of the drill must necessarily be less than the area of the hole in order to provide space for the discharge of the chips. In designing a drill, the object in view should be to produce a section which will give the maximum strength. The stress which a drill is called upon to resist is practically independent of the cutting speed, and with a given feed this stress is proportional to the lip angle of the cutting edge; the cutting stress does not increase



Figs. 4, 5 and 6. Bar for Vauclain Drill before and after Chamfering at O and P

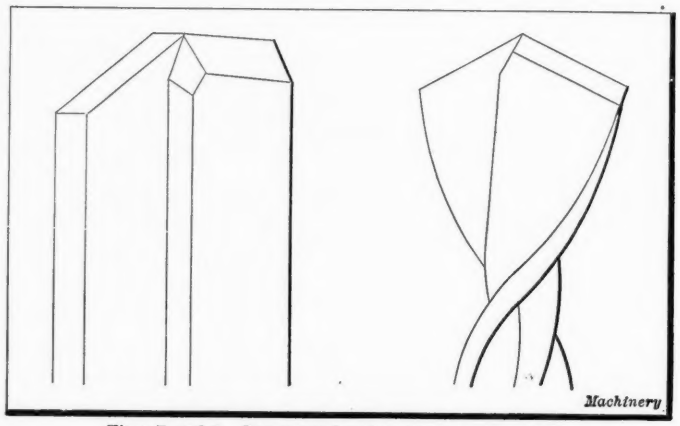
in direct proportion to increases of feed. The rapidity with which cutting heat is generated depends upon the cutting speed, the depth of feed, and the lip angle of the cutting edge. Both the stress and heat generated are influenced by the keenness of the cutting edge; consequently it is desirable that the lip angle shall be as small as possible. It is necessary, however, that the lip shall be blunt enough to carry off the heat and to support the pressure, which falls more or less back of the actual cutting edge according to the depth of the feed.

Under ideal conditions, the torsional capacity of a drill would be its limit of cutting strength. This is not the case, however, in the types of drills which are commonly used, as experience shows that such drills break very considerably below their torsional strength. Under constant conditions of feed, the consumption of power in drilling operations will be proportional to the speed, and if the speed is maintained constant, the power consumed in cutting does not increase as rapidly as the feed. The power consumed by the machine remains constant for all feeds. It will be seen from the preceding, that the most economical method of drilling is that which gives preference to feeds rather than speeds; power, time and drills will be saved by such a method.

Commonly used Types of Drills

Figs. 1, 2 and 3 illustrate the section scheme of commonly used types of drills. This design has been modified in many directions, but the general principle is seen in the position of cutting edges *A* and *B* which pass to each side of the axis of the drill instead of intersecting it. This type of drill has four distinct cutting edges, *A*, *B*, *C* and *D*, and is generally known as a "two-lip" drill, although this name is incorrectly applied. The customary included angle *E* is 118 degrees, which is an unfavorable lip angle for the cutting edges *C* and *D*. These edges constitute what is commonly called the chisel point and their cutting resistance is excessive, thus producing a tendency toward longitudinal fracture of the drill. This tendency to split may be briefly explained by saying that the resistance of cutting edges *C* and *D* is far in excess of that of edges *A* and *B*, with the result that the drill splits close to the axis.

In the commonly used types of drills, there are two possibilities of reducing the chisel point: first, by thinning the



Figs. 7 and 8. Bar ground and twisted to form Drill

drill at its center; second, by pointing the drill. By the former method, the resistance to longitudinal splitting is reduced, and by the latter method, the cutting edges lose their support near the center of the drill. These are the reasons for the limited feed possibilities of the ordinary types of drills, which cause them to break long before their torsional capacity is reached.

Description of Vauclain Drill

The Vauclain drill is especially adapted for heavy feeds, and is capable of working under the most economical conditions. Its design is shown diagrammatically in Figs. 4 to 9, where it will be seen that the strength of the drill is due to the arrangement of the metal in the section. The method by which this section is developed can best be explained by reference to the diagrams shown in Figs. 4 to 9 inclusive. Fig. 4 shows two flat bars overlapping, and integrally connected. By bevel-

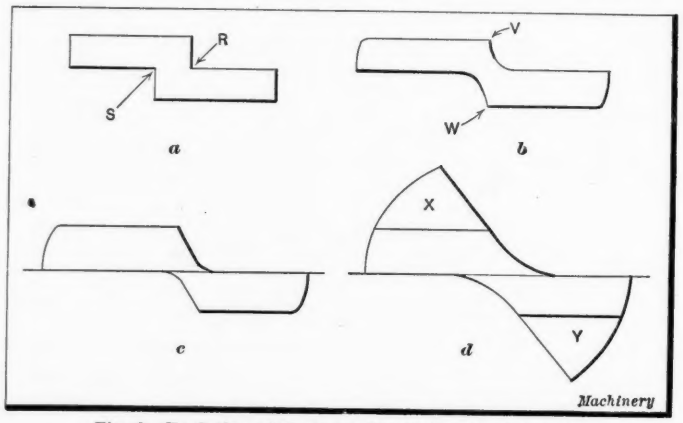


Fig. 9. Evolution of Cross-section of the Vauclain Drill

ing the corners of these bars, as shown at *O* and *P*, in Fig. 5, the edges *A* and *B* are made to meet at the axis of the drill. Fig. 7 shows how the end of the bar appears when ground to form a drill, and Fig. 8 illustrates the same bar after it has been twisted. Fig. 9 shows the same end view of the bar at *a* which was previously illustrated. By introducing fillets into this section at *R* and *S*, the form shown at *b* is produced. The

* Abstract of a paper by A. C. Vauclain and Henry V. Wille, published in the Journal of the A. S. M. E., October, 1912.

corners *W* and *V* are next removed with the result shown at *c*, and the final step in the evolution of the section is attained by adding the areas *X* and *Y*. The result is a drill section which is especially well suited to resist the torsional stresses encountered in the class of work for which the tool is intended.

By examining the diagrams showing the section of the Vauclain drill, it will be seen that the chisel point is eliminated without thinning the central section of the drill, and without weakening the cutting edges. That the drill produced in this way has a considerably increased capacity, will be shown from the result of tests, in which the capacity of drills of this type was compared with that of other drills. These tests were made by drilling a tough grade of forging steel of about 0.45 carbon. In order to secure reliable results, it was

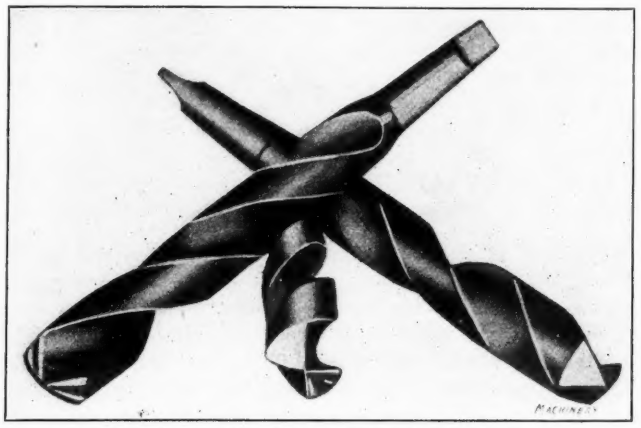


Fig. 10. The Vauclain Drill as finally developed

necessary to compare Vauclain drills with other types of drills made from a similar grade of steel and subjected to similar heat-treatment and tempering. The size of drills used in all tests was 1 9/64 inch. The tests covered such an extensive field that lack of space prevents their being fully dealt with, but the advantages of the Vauclain drill which were demonstrated may be briefly outlined as follows: Under the same conditions of speed and feed 10.86 H. P. was required to drive the regular type of drill as compared with 4.73 H. P. for the Vauclain drill, while in a second case the regular type of drill required 10.30 H. P. to drive it as against 5.03 H. P. required for the Vauclain drill. The advantage of such a condition is not only in the saving of power which is effected, as it is evident that the Vauclain drill cuts so much more easily, that the maintenance cost would be reduced in something like the same proportion. The reduction in cutting resistance would also have a corresponding effect in reducing the tendency of the drill to break.

* * *

AUTOMATIC SPRINKLERS AND INSURANCE RATES

Figures gathered by the Chicago Association of Commerce, showing average insurance rates per $100 in that city, may be partially tabulated as follows:

	Buildings	Contents
Mill constructed buildings, with sprinklers....	$0.23	$0.32
Mill constructed buildings, without sprinklers.	.57	1.04
Ordinary constructed buildings, with sprinklers	.31	.40
Ordinary constructed buildings, without sprinklers	.77	1.19

If the contents of the average manufacturing or storage building are assumed to be worth double the value of the building, a general index for comparing buildings protected with automatic sprinklers and those not so protected is available. Mill constructed buildings on this basis will show an index of 87 for the protected building, whereas that of the unprotected building is 265, or more than three times as great a rate. This means that the reduction in the rate is 67.2 per cent. On the same basis, buildings of so-called ordinary construction would show an index of 111 when protected by automatic sprinklers and 315 when not so protected. In this case the reduction in the rate is 64.8 per cent. The saving effected by the installation of automatic sprinklers will ordinarily pay for the entire sprinkler equipment within a period of five years.

NOTES ON THE EARLY HISTORY OF TAP MAKING

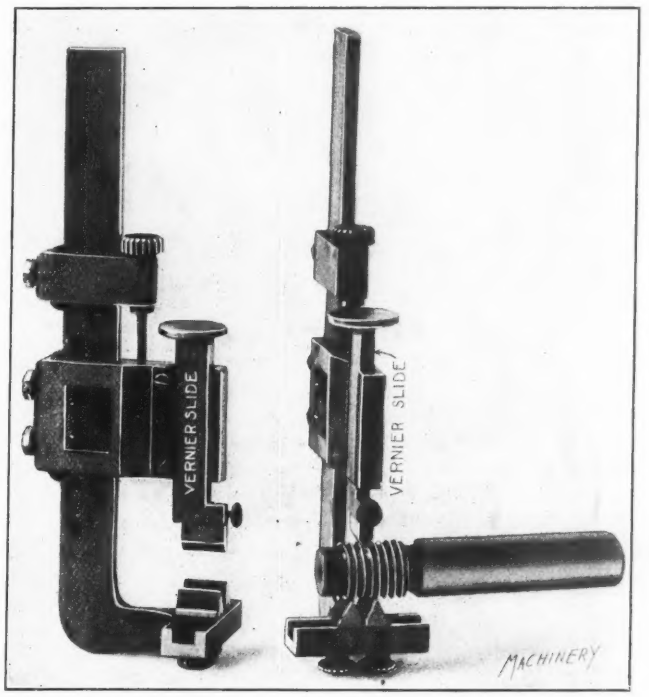
HISTORY OF RADIAL AND TAPER RELIEF—THE CARPENTER THREAD CALIPER—EARLY U. S. STANDARD GAGES

BY ERIK OBERG*

The following information relating to the early history of tap making in the United States has been obtained through the courtesy of the J. M. Carpenter Tap & Die Co., Pawtucket, R. I. A brief account is given of the development of the radial relief in tap making, which, at the present time, has been almost entirely superseded by the back taper relief which was first employed by Mr. J. M. Carpenter in the manufacture of taps as early as 1870. A vernier thread caliper designed by Mr. Carpenter for measuring the pitch or angle diameter of taps and screws, and which was the first of its kind, is shown, and also a set of U. S. standard thread gages, being one of the first sets of these gages ever made.

History of Radial Relief in Tap Making

In 1866, Benjamin Bee, of West Harwich, Cape Cod, a naval engineer, obtained a patent for tap threading machinery. He was successful in interesting outside capital and formed a company under the name of the New York Tap & Die Co., which commenced to manufacture taps on Cape Cod the following year. After some time, however, the factory burned, and due to the influence of outside capital, the business was moved to Bridgeport, Conn., where a new factory was built. The firm of Post & Goddard of New York acted as distributor of the product. Soon after the company had moved to Bridgeport, it became in need of more capital, and Mr. Manning, of Manning, Maxwell & Moore, became financially interested in the concern. Nevertheless, the company finally failed, and



Figs. 1 and 2. The Carpenter Vernier Thread Caliper

Mr. Manning sold the threading machinery, built under Benjamin Bee's patent, to the Morse Twist Drill & Machine Co., New Bedford, Mass., which at that time began to make taps. The machinery invented by Mr. Bee milled the threads in the taps, and also milled a radial relief at the same time, with a round or circular cutter.

About this time, Alfred Goddard, who had been a mechanic in the employ of the New York Tap & Die Co., and who was a brother of Edward Goddard of the firm of Post & Goddard, the distributor of the taps made by the New York Tap & Die Co., brought out a machine similar to that of Benjamin Bee's which produced the same form of radial relief and differed only in that it did the work of threading and relieving with chasers set in a turret head, thus chasing out the thread, while Benjamin Bee milled the radial relief with a circular

* Associate Editor of MACHINERY.

cutter, as mentioned, on his machine. The Goddards induced Mr. Henry Prentiss of New York to finance their venture in tap making and afterward also obtained a loan from a bank in Essex, Conn. They then began to manufacture taps with the Alfred Goddard thread chasing machinery at Essex. The business, however, proved unsuccessful, and the machinery fell into the hands of the bank at Essex that had loaned money to the Goddard Brothers.

The bank attempted to run the business through its president, Mr. J. E. Redfield—as the charter of the bank did not allow it to enter into manufacturing—but as later the business was not successful, the Essex bank sold the threading machinery to the Wiley & Russell Mfg. Co., of Greenfield, Mass., which company still continues to manufacture taps with the radial form of relief.

The Essex bank mentioned, before selling the threading machinery to Wiley & Russell, made an effort to interest Mr. Amos C. Barstow, of Providence, R. I., in the purchase of the Goddard Brothers' machines for the threading of taps with radial relief, and Mr. Barstow's son-in-law, Mr. Cutler, approached Mr. J. M. Carpenter of Pawtucket, R. I., with the proposition of buying this machinery and consolidating the business with that of Mr. Carpenter, who was at that time already engaged in the making of the Carpenter tap. Mr. Carpenter investigated the matter and, basing his opinion upon his mechanical experience, concluded that this method of threading taps was impractical and inferior to the taper relief of his own invention, declined all offers, and continued to put the Carpenter tap with its original taper relief on the market. After forty-three years of successful manufacturing, this form of taper relief has been indorsed by practically all the leading tap makers and users of taps, in that nearly all makers have adopted this method of relief, which was long looked upon as a valuable trade secret. The Wiley & Russell Mfg. Co., however, continued to furnish taps with the radial relief first used by Benjamin Bee of the New York Tap & Die Co., from which it may be inferred that there is still a difference of opinion among tap buyers as to the value of the radial relief.

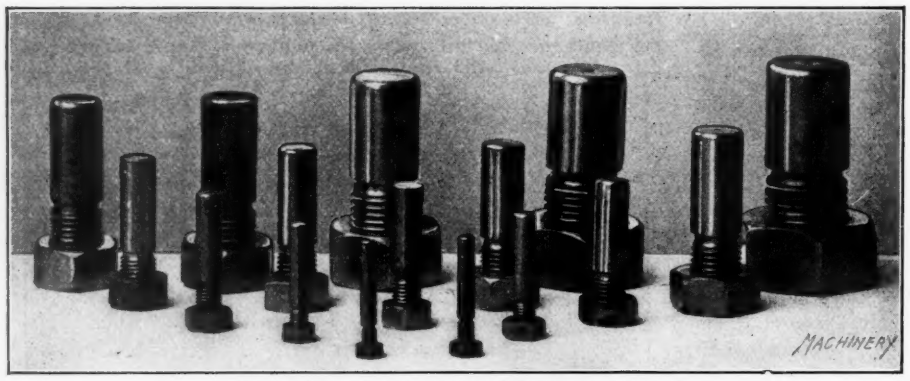


Fig. 3. One of the First Sets of U. S. Standard Plug and Ring Gages made

The First Thread Caliper

The accompanying illustrations, Figs. 1 and 2, show a vernier thread caliper designed by Mr. J. M. Carpenter about 1875. It is without doubt the first thread micrometer ever devised for measuring the angle or pitch diameter of taps and screws, and embodies the principles later developed in the Brown & Sharpe thread micrometer. Fig. 1 shows a side view of the device indicating the provisions for adjustment, while Fig. 2 shows the device in use, the pitch diameter of a thread plug being measured. Up to the time that Mr. Carpenter began to measure taps in this manner, little or no attention had been paid to the angle diameter, all measurements having been taken on the outside diameter of the taps. This, particularly in the case of the sharp V-thread, evidently furnished a very unreliable means of comparison, and the invention of this device for measuring threads in the angle was, therefore, a very decided step towards the standardization of tap dimensions. As is well known, few of the early manufacturers of V-thread taps had any actual standard for the small flat that had to be introduced on the top of the sharp V-thread. Mr. Carpenter, however, at an early date, decided upon rigid limits for the dimensions of this class of taps, and by means of this device for measuring the angle diameter, he was able to maintain his sizes within the limits he had adopted.

Early U. S. Standard Thread Gages

In Fig. 3 is shown an illustration of one of the first sets of U. S. plug and ring gages ever made. In 1868, the Sellers or U. S. standard system of screw threads was authorized for use in the naval service by the Secretary of the Navy, and shortly after, fifteen sets of plug and ring gages ranging from ¼ inch up to 3 inches in diameter were ordered by the government from Mr. George Fox, of Boston, maker of a chasing lathe known as the Fox lathe. When making these sets, Mr. Fox also made up a number of extra sets, of which Mr. Carpenter bought the last two complete sets, and part of a third one which he himself afterward completed. The illustration shows one of these original sets made by Mr. Fox, which are still in the possession of the J. M. Carpenter Tap & Die Co.

* * *

HIRING HELP

BY ABAN SAW

"It surely is a tough proposition," remarked the master mechanic to me a few days ago, "to pick up a good mechanic nowadays when you are most in need of him. Why, I could put on ten more men in this very department right off, if the right ones were available. That 'dub' who just called me out to the time office and said he ''eard as 'ow I was looking for an electrician'—well I am looking for one still. Of course I asked him if he was an electrician and he said 'Yes.'"

"'What can you do?'"

"'Anything from making a dry battery to running a dynamo,' was the reply of Johnnie Bull."

"'Well,' said I to test him, 'what is necessary to be done in order to run a dynamo in the opposite direction of rotation?'"

"'Same as on a steam engine.'"

"'What's that?'"

"'You shift the lever the other way!'"

"Well that capped the climax and I soon sized him up as a first-class bluff—a good one, say, to edit articles for some kid's paper. I thought, just for the fun of it, I would try him on his first occupation—making dry batteries—so I said: 'How many ammeters in an ordinary dry battery?'"

"'Two,' was the prompt reply."

"'A dry cell that contains less than four is considered worthless,' I informed him. 'All dry batteries are worthless,' he replied. 'Yes, and so are you,' said I, giving him a wave towards the open door.'"

"The next fellow who came along stated that he was a 'blueprint machinist.' I asked him where he got the title and he said that he saw my 'ad' for a first-class machinist who could read complicated blueprints. Well, I thought I might possibly use him in the snagging room, so I put him to work. Well, sir, in the three hours that he was in there he did more fool tricks than a green apprentice boy trying to harden a scriber made of coil solder. The first job, he was told to take off the emery disk and put on the rag wheel to buff up those valve handles. He got the disk off all right, but couldn't for the life of him put the rag wheel on. First he tried to screw it on right-handed, then to pound it on, and finally he brought it to Jim, the other polisher, and asked him for one with a larger hole. He even put paraffine on one of those twelve-inch bastard files to stop the chattering when he was taking the burr off of a piece of sheet steel."

"Oh well, I wish some of the trade schools would send out some more first-class machinist improvers. They are worth twice as much as any two of these pieces of humanity traveling from place to place trying to hold a job."

IMPROVING THE EFFICIENCY OF A CHECK-ROOM

BY R. H. WADSWORTH*

Efficiency in a shop involves a study of all the conditions, methods, and appliances related to maintenance and production, and an intelligent effort to perfect each detail. This study should not be confined to jigs and tools, but should also be extended to a large number of conditions which, at first thought, seem to be too remote to prove fruitful fields of investigation. The following account deals with a shop once under the writer's jurisdiction, showing conditions that formerly existed and the increase in efficiency that was secured in the check-room system for tools and blueprints.

For an entire day, notations were made concerning each man who came to the check-room window, and how long he waited. It was found that a total of twenty-three hours was spent in this way, three check-room attendants being kept busy. The number of men who had occasion to call was about 150. The length of time they waited was from half a minute to nine minutes, and two calls were still longer.

The original arrangement of the check-room is shown in Fig. 1 and the improved arrangement in Fig. 2. It will be

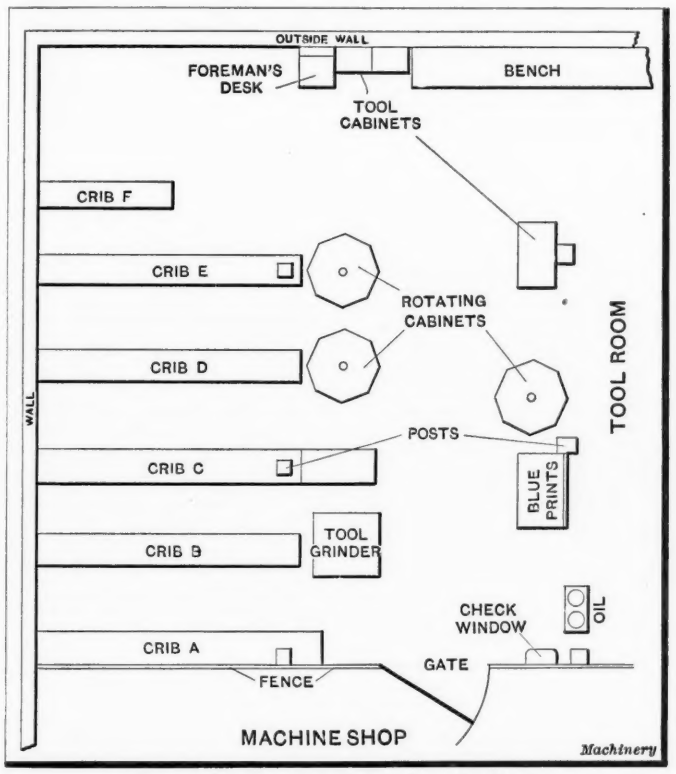


Fig. 1. Original Arrangement of the Check-room

observed that there was originally no partition between the check-room and the tool-room. All persons desiring to enter the tool-room came through the door leading from the machine shop to the check-room. This feature was annoying to the attendants, and made it impossible for them to be accurate in their work. The evidences of trouble were seen in lost checks, misplaced checks, and tools gone without checks in exchange. Every time such matters were brought to the attention of the head attendant, he excused himself on the grounds that the trouble was beyond his control: that both the shop men going through the tool-room and the nearby toolmakers frequently helped themselves to anything they wanted when the attendants were busy, and that these men could not be depended upon to leave their checks. Blueprints were kept in the shallow drawers of a cabinet, and pieces of sheet iron nearly as large as the drawers were laid on top of the blueprints to keep them from curling up. Occasionally a blueprint would slip out at the back of the drawer and get lost.

The check-room window was about 24 inches wide and 12 inches high, and at such an elevation that shop men could not see the attendant without stooping. There were three octagonal, revolving cabinets having bins in which such small tools as taps and dies were kept. To find any article, the attendant would rotate the cabinet two or three times before getting what he sought. Poor lighting, together with the further loss of light because of the size and location of these

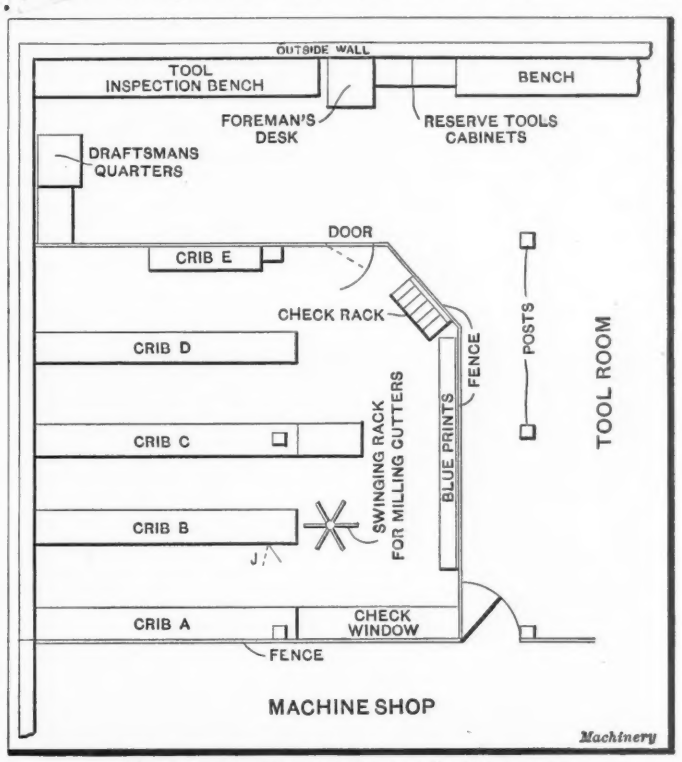


Fig. 2. Improved Arrangement of the Check-room

large revolving cabinets, made the work of the attendants still more difficult.

The first step taken to improve matters was to build a fence of woven wire separating the check-room from the tool-room, as shown in Fig. 2. The entrance to the tool-room from the machine shop was placed to the right of its former location,

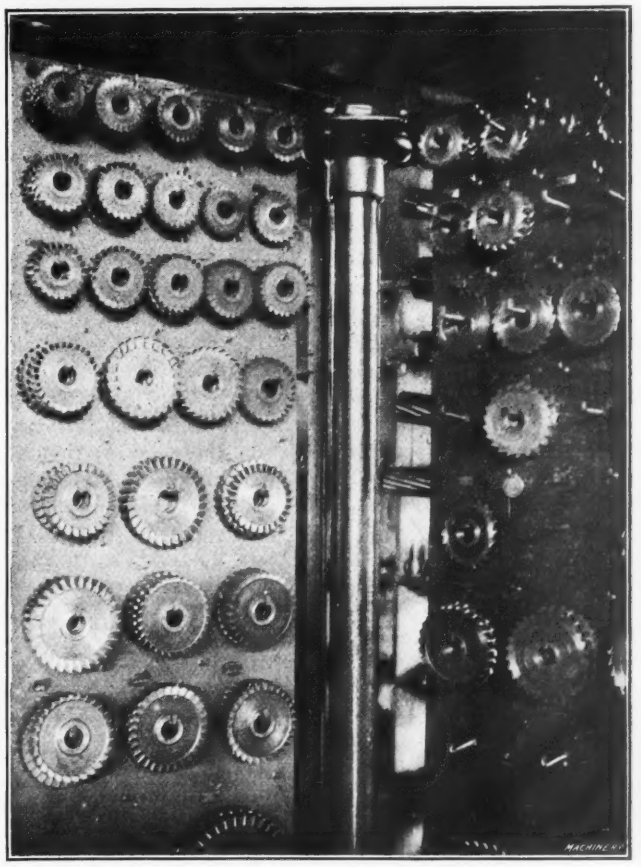


Fig. 3. Special Rack made for carrying Milling Cutters

so that it was outside the check-room. The only door entering the check-room was located near the desk of the tool-room foreman. This door was kept shut by a spring, and secured by a snap latch on the inside. Anyone desiring to enter the

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check-room was thus unable to do so until he had satisfied the attendant as to the necessity for so doing. The window opening to the machine shop was made 10 feet long and 2 feet high. The door which closed this window out of work hours served as a big counter when open, and the men of the shop were served with tools and prints over it. A small window in the side fence accommodated the toolmakers. A large cabinet was set up under the big counter in which the small tools were deposited. Under the old system, tool cribs *A*, *B*, *C*, and *D* were mostly filled with obsolete tools and machine parts. About three tons of this stuff was scrapped, and the remainder moved to the rear. The new tools, formerly stored in cribs *E* and *F*, were brought forward to *A* and *B*. The tool grinder was not in service; consequently it was removed to make room for useful tools.

One of the revolving cabinets was dismantled, and a pair of

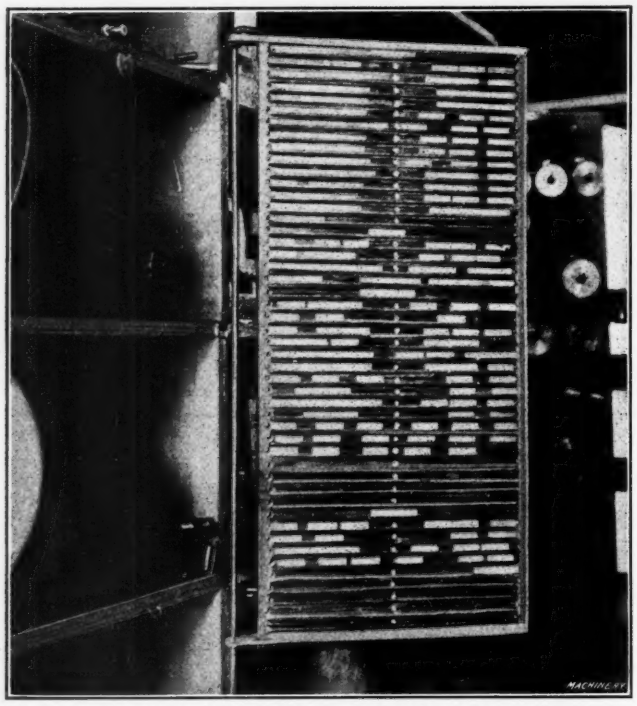

Fig. 4. Rack for carrying the Flexible Card Index of Jigs and Fixtures

flanges about 10 inches in diameter were mounted on its spindle, one at the top and the other near the bottom. Eight boards were cut about 6 feet long and 20 inches wide. Straps of soft steel 1 by ⅜ inch were secured to each end of these boards, about five inches of the straps extending beyond the edges of the board. These boards were then mounted upon the spindle of the former revolving cabinet, the straps resting upon the flanges and being secured by one bolt through each strap and flange. This permitted the boards to swing upon the flanges like the leaves of a book; in addition to this movement, the spindle and flanges could be rotated about the supporting spindle. Fig. 3 shows the upper part of this stand, which was placed near the check-room window so that shop men could see to select from the array of milling cutters on it, and ask the attendant for what they required, without entering the check-room. A board about 14 inches wide and 36 inches long was hung from the side of a tool crib, as shown at *J* in Fig. 2; the board itself is shown in detail in Fig. 4. Strips of sheet steel, bent as shown in Fig. 5, were attached to this board, and small cards, each bearing the number of a jig or fixture and its location, were inserted in the manner shown. The flexibility of this arrangement made it possible for new cards to be inserted, or the location of tools to be altered in the cribs and still allow the numbers of jigs and fixtures to be kept in numerical order on the board.

Fig. 6 shows the new arrangement of the blueprints on racks; these racks were made of sheet steel, as shown in Fig. 7, and secured to 2 by 4 timbers. The numbers of the blueprints were written on stickers and pasted on the steel racks. Several prints of each number were carried on a single rack,

Fig. 6. Method used for filing Blueprints

and the length of the rack was varied in different rows to suit the dimensions of the prints. As will be seen from the illustration, there were three rows of racks; each row was ten feet long, and there was a total of 1350 racks. A small card index was provided, giving the size of the sheet for each drawing number. Checks were taken in exchange for blueprints, and these checks were hung on hooks on the racks shown in Fig. 8. The drawing number of every blueprint in stock was marked on a piece of cardboard and inserted in numerical order in the steel strips above the hooks; these

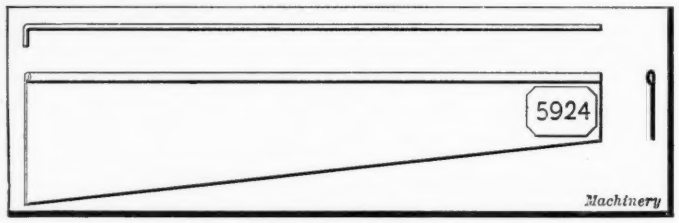

Fig. 7. Detail of Blueprint Rack and Method of mounting

strips were of the same design as those on the index board for jigs and tools, shown in Fig. 5. The hooks were arranged nine in a row, and there were sixteen rows on each side of seven boards, making a total of 2016 hooks. The total number of different drawings in use was less than a thousand, but their numbers ranged from 125 to 6000. This range of numbers required an arrangement of great flexibility or great space to accommodate the checks. This device gave the required flexibility in small space, as the cardboards could be rearranged at will, to insert new numbers or remove those not in use and still retain the numerical order.

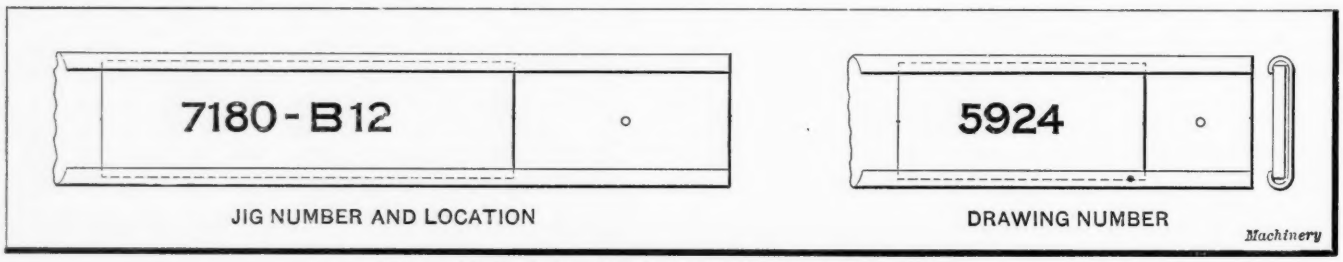

Fig. 5. Method of attaching Card to Rack shown in Figs. 4 and 8

The number of both standard and special tools that are required with drill jigs is frequently greater than the number of checks allowed to an operator. This formerly required him to borrow checks or get tools on memorandum. Both methods have their defects. To assist in the solution of this problem,

we placed a brass plate on each fixture on which was stamped the number of the fixture, its location in the tool crib, the name of the piece for which it was made, its part in the production of that piece, and the number and description of the special tools which were required for use with the fixture. For the fixture and tools mentioned on the plate, only one check was required. The information on the plate was of service to both the operator and the check-room attendant, and was of great assistance in accounting for tools in the shop. One of these brass plates is shown in Fig. 9.

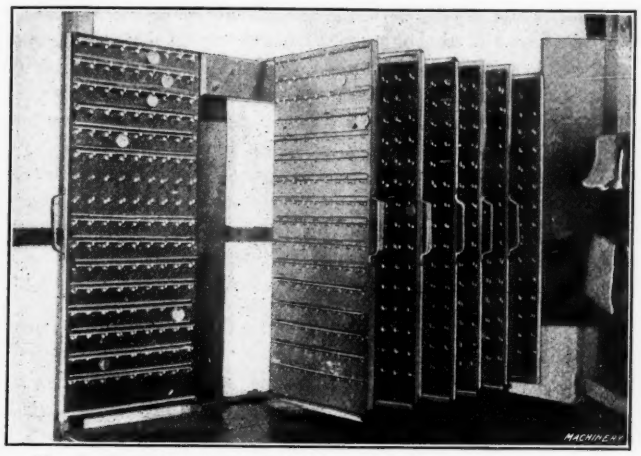

Fig. 8. Rack for filing Checks taken in exchange for Blueprints

When these changes in our tool-room method were put into effect, it was found necessary to keep only two attendants in the check-room, where three were formerly employed, and these men were not always busy. A study of the time employed by men waiting at the window was again made, and it was found that but fourteen hours was thus employed instead of twenty-three as at first. Taking the average rate of all men calling at the check-room window at 25 cents per hour, we find a saving of $2.25 in a nine-hour day. The rate of the attendant who was dispensed with was 15 cents, or $1.35 per day. This makes the total saving $3.60 per day.

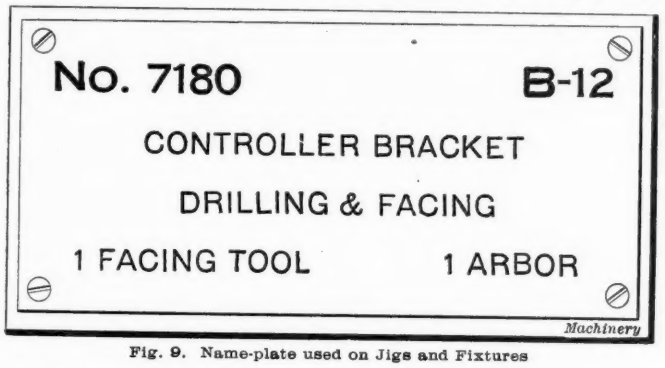

Fig. 9. Name-plate used on Jigs and Fixtures

For 300 working days per year, the annual saving would be $1080, without including the larger production of the machine operators that has been made possible. The change was accomplished at a cost of less than $100.

For his efficient cooperation in bringing about these improvements, the writer desires to acknowledge the services of Mr. G. W. Linn, then in charge of the tool-room and check-room.

* * *

GERMAN MACHINE TOOL IMPORTS AND EXPORTS

During the first six months in 1912 the exports of machine tools from Germany amounted to 36,624 metric tons, as compared with 27,061 metric tons during the first six months in 1911, and 26,871 tons during the first six months in 1910. The largest percentage of exports was shipped to Austria-Hungary, with France, Russia and Italy coming next as the best customers of German machine tools.

The imports of machine tools into Germany amounted to 4459 tons, as compared with 3396 tons during the first six months in 1911, and 3224 tons during the first six months in 1910. Of the imports the United States supplied more than 60 per cent, the imports from the United States increasing from 2100 metric tons during the first six months in 1911 to 2819 tons during the first six months in 1912.

ANNEALING HIGH-SPEED STEEL

BY A

The method which seems to be most generally used for annealing high-speed steel is as follows: The high-speed steel tools or pieces to be annealed are packed in air-slacked lime in iron boxes of suitable size. Care is taken not to let any of the tools come in contact with each other, and to see that they are well surrounded by the lime. The boxes are covered by iron covers and the openings between these covers and the boxes are smeared over with fireclay so as to prevent any air from reaching the contents of the boxes. The boxes are then put into the annealing oven and the latter is heated, with the boxes in place, to from 1900 to 1950 degrees F. for not less than nine or ten hours. The heat is then shut off and the boxes left in the oven to cool off with the furnace, and are taken out first when the furnace is cold.

This method invariably produces good results, the tools being soft and evenly annealed, but it is very expensive. In the first place, considerable time is taken in packing the tools, and the man employed on this work must be a man that uses considerable judgment and care in his work. Then there is the cost of the fuel for maintaining this high heat for the length of time mentioned, and, in addition, the cost of the iron boxes which seldom can be used more than once on account of the high heat to which they are subjected. For these reasons the new method described in the following will be found advantageous. This method is much quicker, and if the instructions are conscientiously carried out, it will be found to be as effective as the one just outlined. The new method is as follows:

Pack the tools to be annealed directly in the oven, one on top of the other, the furnace being entirely filled if necessary. Then heat the furnace to a temperature not exceeding 1700 or 1750 degrees F. It should not require more than three hours for the furnace to reach this heat, which is then maintained for about two hours more, or, until the temperature of all the tools has been raised to that of the furnace itself. (When smaller pieces are to be annealed, it is therefore, sufficient to maintain the heat for only one hour.) Then shut off the heat and at the same time close all holes, such as burner and draft holes, as carefully as possible, and let the tools cool off in the furnace. This cooling takes place very much quicker than when the first mentioned method is used, because the tools are not packed, and, hence, there is a saving in time not only in the heating but also in the cooling. The greater part of the expense of annealing is thus saved on account of the saving in fuel, and the elimination of the packing, packing materials and the boxes.

* * *

RELATION BETWEEN HARDNESS AND WEAR OF STEEL

In a paper presented before the International Association for Testing Materials, at its congress in New York, September, 1912, Mr. E. H. Saniter stated, as the results of experiments made, that there is no definite relation between hardness, as measured by the Brinell hardness testing method, and wear. While, in general, a high Brinell hardness number may be expected to indicate a metal which will give better wear, there are so many exceptions that this test for indicating wearing properties would be unreliable. As an example, it was mentioned that Hadfield's manganese steel, which has a low Brinell hardness number, proved the best steel as far as wear is concerned in the wear tests undertaken. However, the relation of either Brinell tests or ordinary wear tests to wear in actual practice is a subject which requires further investigation, and it is not certain that the ordinary type of wear test is a fully reliable indication of the wear a certain material may give when in use under certain conditions. It would seem, from opinions expressed at the congress for testing materials, that wear tests should be made along different lines according to the actual uses to which the metal is to be put.

* * *

A fair day's work well done, good habits and a good name usually keep pretty close company.

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UNPROFITABLE REPAIRING OF TOOLS

Machines and tools are often repaired and kept in use when it would be more economical to buy new ones. Some men even pride themselves on what they call the savings resulting from this patching up of old tools. A story that illustrates the extremes to which this habit of repairing old tools can be carried was recently told by the mechanical engineer of a plant making machinists' tools.

A complaint was made to the sales department by a toolmaker, who stated that nippers of the firm's make did not stand up well. He mentioned in particular that when he worked at the Jones & Smith Co. one of these nippers was sent over to the toolroom for repairs at least twice a year. The tool in question did not cost more than $2, and had apparently been used for something like five or six years. When asked how long it took him to repair the nippers, the man making the complaint said: "Well, I should say about half a day." He was asked what wages he received, and promptly replied that he was a first-class toolmaker receiving forty-three cents an hour!

It requires no elaborate cost system to point out this moral; yet similar instances are not of unusual occurrence, particularly in the case of the smaller tools used around a machine shop, and the loss on such wasteful repairs may amount to a considerable sum during the year. Often this is caused by a mistaken theory of economy on the part of a foreman, but quite as often the general policy of the management of a shop is at fault. The foreman of the department or the superintendent of the plant has so often been cautioned by his manager against "unnecessary" expenditures, that he tries to avoid sending in requisitions for new tools, and prefers to put one or more of his men to repairing old ones, because this work will not show up directly in the expense account, but will be charged to general repairs. Many a foreman remembers well how he has been requested to explain in detail the reason for buying a new device or tool costing but a few dollars, while at the same time wasteful methods of doing work which absorbed daily several times the cost of a new appliance, might be passed by unnoticed. What is needed is closer cooperation between the heads of concerns and the men in charge of the various departments. In many instances considerable economies could be effected if foremen and superintendents were encouraged to follow their own judgment with regard to the buying of new tools and the repairing of old ones; or, if this policy in some cases would not be advisable, they should at least be encouraged to state their opinions freely, as it is likely that by their cooperation a great many false economies could be eliminated.

* * *

THE NEED OF POWER

The steam engine is such a common and necessary part of our civilization that few stop to think what a debt we owe to it. The need of man in his struggle with the crudeness and rawness of natural resources has been, is, and always will be for power. He is a comparatively weak creature, barely able to supply his physical needs by unremitting toil if unassisted. The first upward step from savagery was made when a cave man of splendid courage conquered the wild horse and trained him to carry burdens. The harnessing of horses and cattle to the plow was another great step forward that reduced manual labor and increased food production. Removed from the fear of immediate starvation, the needs of the mind as well as the body were ministered to and the march upward toward the civilized state was well begun.

But unhappily the opportunity to live on a higher plane was for only a few. The great mass was still submerged in poverty and in a state of actual or practical slavery. The ancient Greeks believed that civilization without slaves was impossible, and it was true of the conditions then existing. Without power other than that of animals, men must be employed to serve their masters to those comforts and luxuries that the higher life demands, but which the servers could not hope to enjoy themselves.

The invention of the steam engine and the great improvements made by Watt marked a new era which has had no parallel, and, therefore, is not comparable with any recorded epoch of the world's history. While elemental human nature does not change, the environment of man has so changed that predictions of the future based on the past are futile, if not foolish. But we know that human servitude has not yet been abolished; it has taken on new forms less galling physically, but still intolerable to sensitive minds. How can liberty be attained? Only by acquiring the means of developing more power.

The growth of a great modern city is consonant with the development of power stations to supply its railways, lights, elevators, manufactories and other urban activities. The energy developed in one comparatively small unit is greater than all the available working force of some of the proudest ancient empires. The great Curtis turbine of the New York Edison Co., developing 30,000 H. P., is the physical equal of over a million men working in three equal shifts throughout the twenty-four-hour day. What a tremendous multiplication of the dynamic energy of the comparatively few men required to attend it and the boilers generating the steam needed to supply it! It is this great multiplier of human force, applicable in one way or another throughout the world, which is required to realize the ideals of the advanced engineer. To make the world small, to bring the produce of the uttermost parts to its markets and distribute the products of manufacturers to those who have furnished the food and crude materials, is the great problem of the age. It is the problem of distribution that the engineer must solve as well as that of production; and power in all its many manifestations is the one great necessity for its accomplishment.

GAS ENGINE CAMS

It is a curious feature of gas engine design that the simple, primitive form of valve lifter cam, that is, the form in which the contour is made up of arcs and tangents, is less noisy than the more refined shapes which have often been proposed and but little used. To one familiar with the laws of mechanics and the general requirement to overcome the inertia of matter gradually and progressively to prevent shock, it is natural to conclude that an accelerated motion cam would work more smoothly and create less noise than that shape commonly used in which the lifter is practically a V-shaped boss on the side of a semicircular hub.

The article begun by Mr. Terry in the November number, and concluded in this number, exhaustively analyzes the conditions of gas engine cam action and shows why the primitive form is after all best. The article is lengthy, and so far as the conclusions are concerned it can be summed up in a comparatively few words, but we believe, nevertheless, that the space required for the elaboration of the analysis will be profitably used. It should settle once for all this question, which has caused no little discussion and perplexity among automobile engine designers. The case is one in which rule-of-thumb designing seems to have the best of it and theory to be at fault, but this is only apparent. When all the theoretical considerations are given their due weight, we can clearly see why the supposed refinement of cam design is not an improvement but actually a detriment.

* * *

REFORMING THE PUBLIC SCHOOL SYSTEM

As the defects of our public school system are brought out more and more by the educational deficiencies of the boys entering shops and factories at an early age, the more apparent it becomes that steps should be taken to correct them. Under the present system the public schools are open five days a week, from thirty-nine to forty weeks a year. The pupils go to school considerably less than two hundred days in the year; taking out the holidays, the average is about 190 days.

When it is considered that the children of the working classes have to leave school at fifteen or sixteen in order to contribute to the family support, the question is: "Why not try to improve the years when they can go to school"? Continuation schools are merely to make up for lost time. The average boy and girl in the towns and cities would be better off going to school six days a week fifty weeks in the year than loafing around, as many must, during the vacation period. This schedule would give them fifty per cent more hours of school work in a year, and that would be equivalent to two years extra schooling between the twelfth and sixteenth years. The boy who has to leave school at sixteen under this schedule should be as far advanced as he is at eighteen under the present system.

The arguments against the continuous school term are the strain on teachers, objections of parents, hot weather in July and August, and the need of pupils for long seasons of rest. As to the teachers, it is hardly necessary to point out that employes in stores, mills and factories work longer hours every day in the week and in many cases every week in the year. The parents' objections would become inconsequential when the benefits of the plan became apparent. School buildings can be made cool in summer, and will be made comfortable when the continuous school term becomes general. Pupils advance relatively faster when the school work is continuous. Several days or weeks are lost every opening term in the process of getting back into harness and regaining the receptive frame of mind largely lost during the vacations.

The continuous school term is being tried in several cities and towns with satisfaction. A feature of no little importance is that the better utilization of school buildings has lessened the need of new structures, meaning a saving of thousands of dollars annually in a large city. But the chief advantage is that the general adoption of the continuous school term will raise the educational standard of the workers' children to a plane that will better fit them for their duties not only as efficient industrial workers, but also as citizens.

LOCATING BALANCE WEIGHT CHAINS ON HORIZONTAL BORING MACHINES

BY W. G. DUNKLEY*

The most frequent problem met with in determining the correct location for the balance weight chains for the spindle slides of horizontal boring machines, is that in which the slide is under-balanced. In this case the difference in weight between the spindle slide and the balance weight is carried by the vertical screw. Consequently, there is a reaction on the slide, equal in value to the load on the screw, which acts along the axis of the screw. If the presence of this reaction is ignored, it will give rise to a turning moment on the slide which will cause the latter to bind on the upright. Such a binding action between the slide and upright would have been avoided if the proper means had been taken to locate the balance weight chains correctly. It will be readily understood from the preceding that the location of the balance weight chains is a matter of considerable importance in the design of horizontal boring mills.

In order to enter into this subject in detail, a case will be considered in which the spindle slide weighs eight tons and the balance weight only four tons. In this case, the reaction of the screw on the slide is equal to the difference between the weight of the slide and counterweight, or four tons. The load on each chain is two tons, as illustrated in Fig. 1, and, as a result, the vertical downward force of eight tons is balanced by the vertical upward forces, which have a total value of eight tons as shown. The slide is not in equilibrium, however, unless the moment of all the forces about any point is zero. If the moment of the vertical forces on the slide about any point is not zero, this moment must be balanced by a moment due to the reactions Q of the slide on the vees, because the slide is in equilibrium. In this problem, the friction between the slide and the face of the column is neglected. The center of gravity of the slide is located on the line CC which is ten inches from the screw. With this data at hand, the problem consists in determining the correct location for the chains. Bearing in mind that the reaction of the screw is four tons, the chains should be placed as indicated by the full line arrows, and with such an arrangement, the vertical forces are depended upon to keep the slide in equilibrium. There may still be a tendency for the slide to turn in a plane at right angles to the face of the upright.

Neglecting the reaction of the screw, the chains will naturally be placed at equal distances on either side of the center of gravity of the slide, as indicated by the dotted lines in Fig. 1. With such an arrangement, the turning moment of the vertical forces about an axis at the center of gravity will equal $4 \times 10 = 40$ ton-inches. This moment has to be neutralized by the moment of the forces Q which are determined as follows:

$$Q \times 60 = 4 \times 10 \times 2000 \text{ pound-inches.}$$

$$Q = \frac{4 \times 10 \times 2000}{60} = 1335 \text{ pounds}$$

This twisting action on the slide may attain a still greater value for increased inaccuracy in the location of the counterweight chains, but where these chains are properly placed, the presence of any twisting forces Q on the slide will be entirely avoided.

In some cases an additional chain is provided at the outer end of the slide, as shown at E in Fig. 2. Where such a design is adopted, it is necessary to provide an auxiliary standard to carry the balance weight. Where this practice is followed, it is necessary to be particularly accurate in designing; otherwise the arrangement is open to question, so far as the turning moment on the slide is concerned, but in any case the result secured will depend largely upon the location of the center of gravity of the slide. For example, if the slide shown in Fig. 1 were balanced according to the design shown in Fig. 2, the turning moment due to the vertical forces on the slide would be 130 ton-inches, 120 ton-inches of which would be due entirely to the force at E. In such a case, the amount

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of the moment Q due to the reaction of the vees would be considerable, with the result that there would be excessive binding of the slide on the upright.

Let us next consider a case in which the center of gravity of the slide lies on the line *DD* shown in Fig. 2. The twisting moment due to the vertical forces would then be zero, and in such a case the action of the slide will be free from any tendency toward binding. There is one point about the arrangement shown in Fig. 2 that is particularly worthy of attention. Any alteration of the load at E will give a corresponding alteration of the reaction of the screw on the slide, which will result in a considerable variation in the twisting moment on the slide. This makes it possible to vary the load at E until the slide is properly balanced and binding action

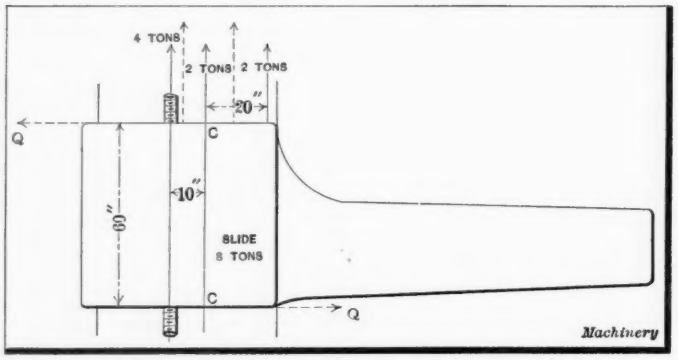


Fig. 1. Correct and Incorrect Methods of balancing Slide with Two Chains

eliminated; in this way, any inaccuracy in the calculation of the position of the center of gravity may be compensated for.

The calculation of the center of gravity of a heavy slide is not a simple matter, and as a result, it is apt to be avoided. This is obviously poor practice, as the proper action of the slide on the upright has been shown to be dependent upon having the counterweight chains correctly located in regard to the center of gravity of the slide. For example, the vertical hand adjustment of the slide is sometimes difficult to accomplish, and is made even more difficult if there is an excessive binding action between the slide and upright. In the preceding discussion, the balance of the slide has been treated for cases where the slide is stationary. Since there is binding action between the slide and upright, due to the resistance of the cut when working, it is obviously desirable that the binding action should be reduced to a minimum when the

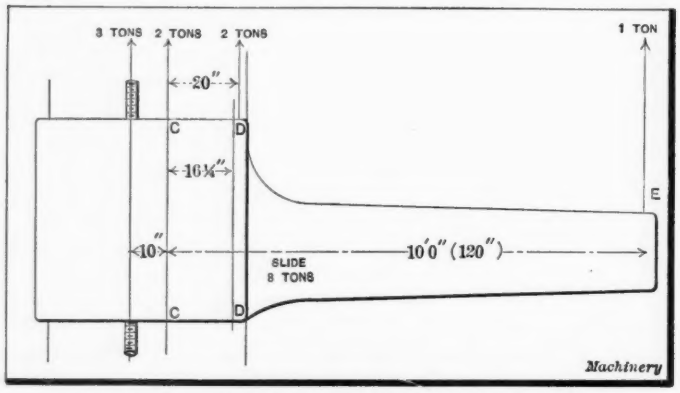


Fig. 2. Correct and Incorrect Methods of balancing Slide with Three Chains

slide is stationary. In some cases an attempt is made to put the screw under the center of gravity of the slide, but a consideration of the conditions shown in Fig. 1 will make it evident that there is no necessity for so doing in order to obtain a proper balance. For example, let us consider a case where the slide is engaged on a milling operation. In such a case, the force of the cut introduces an additional force between the screw and the slide, with the result that the turning moment on the slide, due to the force of the cut, is equal to this force multiplied by the distance between the screw and the line of the cut. It is thus evident that the screw should be as near the cutting face as possible, in order to reduce this turning moment to a minimum. If the screw is made to coincide with the position of the center of gravity of the slide, the distance to the face of the cut is increased; consequently it is not advisable to do this in order to obtain the desired balance of the slide, on account of the increased twisting moment that is introduced. The width of the guiding surface does not enter into the calculations in any way.

* * *

THE PYROMETER AND TIME STUDY IN STEEL TREATMENT

The general experience of a maker of lathe and planer cutters for tool-holders, outlined briefly in the following, shows how necessary are exact scientific methods to insure the production of uniformly satisfactory high-speed steel tools:

"Investigations in machine shops and tool-rooms indicate that the fault of most importance to the managers, is the lack of uniformity in results obtained from high-speed cutting tools. Many places were found where attempts were made to treat steel by faulty methods or with inadequate facilities. The lack of pyrometers, failure to use pyrometers when provided, hardening in charcoal furnaces insufficiently heated and treating without preheating, were a few of the practices noted that produced ununiform results—a few good pieces and many almost worthless.

"It seems to be the general opinion among those not getting results, that pyrometers are not of much use, that they do not give correct readings, and that better results can be gotten by depending on a man's experience than on any mechanical device. Now in the treatment of cutters we have had failures with pyrometers, but at the same time have found the cure for it, and that is frequent calibration. There is no question but what a man's eye is a better judge of the heat in a furnace than an incorrectly calibrated pyrometer.

"In the treatment of our cutters we have probably employed no more skilled men than are used in many large plants for treating high-speed steel, but the methods that they use and depend on are scientifically correct. Since the adoption of the improved Taylor-White treatment of high-speed steel we have sent out thousands of cutters and have received practically no complaints. Our experience has shown that a cutter treated today is the same as one treated six months ago and will be the same as one treated six months from now. We have tested all makes of high-speed steel, and have proved that with proper heat treatment any one of four or five of the real high-grade high-speed steels is entirely satisfactory and, in fact, cutters made from all of them cannot be told apart in use.

"All our cutters are preheated in a low-heated furnace at a temperature of 1350 degrees F. This heating takes out all strains in the metal and puts it in the best possible condition for bringing quickly to the high heat necessary to get the best results from high-speed steel. Every cutter from the smallest to the largest is treated in accordance with its sectional area and size. It goes from the low heat into the high heat furnace and stays there for a time that has been determined for each size by tests. We use pyrometers constantly on both furnaces, which are tested twice a week, having found that this is as long as they can safely go without being checked. The heat-treating room is provided with a specially made clock which starts on the pull of a lever by the man running the furnace, who knowing the proper length of time required for the cutter being treated, sets the clock accordingly. At the end of the predetermined time the clock rings a bell and stops, and the operator takes out a cutter and puts it into the proper medium.

"Our experience shows that it is necessary to bring the high-heat furnace to a temperature above the melting point of high-speed steel to get satisfactory results. This, of course, requires positive accuracy of the time chart as a fraction of a minute too much in the furnace would ruin the cutter, and too short a time would not give sufficient heat. Another reason for this is that to get the best results from high-speed steel, it is necessary to quickly raise the heat from 1350 F. to the highest heat required.

"We believe that the essentials for proper treatment of high-speed steel are: a first-class quality of high-speed steel, preheating, quickly raising the temperature of the steel to the proper quenching heat in a high-heat furnace, the use of accurately calibrated pyrometers and a correct time chart."

* * *

The Harvard engineering school has recently instituted all-the-year-round courses. The course for master's degree in engineering now can be taken in two years, there being no summer vacation. The students work from eight to ten hours per day, and the total vacations in the year amount to only about four weeks. The University of Chicago has also for some years maintained a summer term having equal weight with the other three-quarters of the year. This is a movement in the right direction. The inefficiency and waste of time due to the time-honored system of long summer vacations is out of place especially in engineering schools.

SPECIAL KNURLING OPERATIONS*

PRACTICE FOR THE BROWN & SHARPE AUTOMATIC SCREW MACHINES

BY DOUGLAS T. HAMILTON†

The knurling operations dealt with in the previous articles by the writer are what might be called "standard," and are met with frequently in automatic screw machine practice. The following examples are more of a special nature, and illustrate unusual applications of knurls. The data which follows should be of suggestive value to the designer of screw machine tools, inasmuch as it presents commendable methods of applying knurls to the work under varying conditions.

Bevel Knurling Tools Operated from the Turret

The simple bevel knurling tool shown in Fig. 2 is provided with a tapered shank and is held in a standard floating holder in the turret. The piece to be knurled, *A*, is a small German

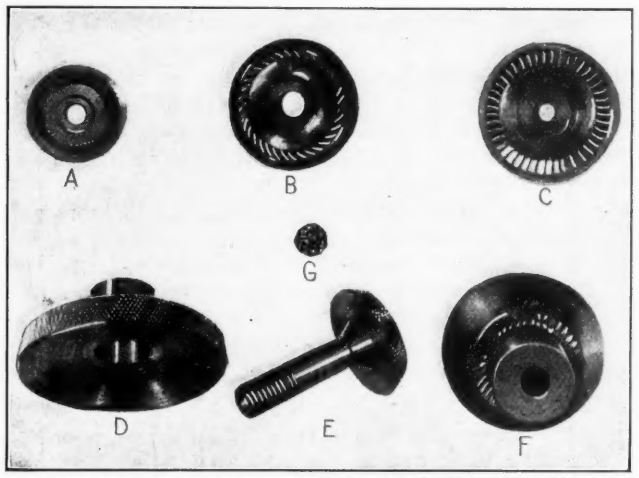


Fig. 1. Examples of Work requiring Special Knurls and Knurl-holder Applications

silver button which has a convex face, but as the curvature is slight, a straightface diamond knurl can be used. In applying the knurl to the work, the center line *BC* of the knurl should be at right angles to that portion of the work it is required to knurl. This particular holder was used in a No. 00 Brown & Sharpe automatic screw machine, which was operated at a spindle speed of 1492 R. P. M., and with a feed to the knurl of 0.0023 inch per revolution of the work.

Another example of end-knurling from the turret is shown

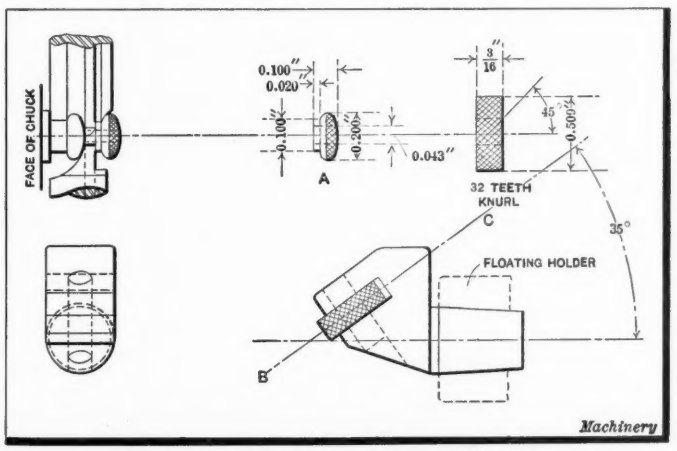


Fig. 2. End-knurling Tool held in Floating Holder

in Fig. 3. The piece to be knurled is shown at *A*, and also at *F* in Fig. 1. The knurl is presented from the turret under the body of the work, and produces a single spiral knurl, the teeth of which are at an angle of 25 degrees with the axis of the work. The holder is held in a No. 2 Brown & Sharpe automatic screw machine, and the work is rotated at 1200 R. P. M., with a feed to the knurl of 0.0024 inch per revolution.

The knurl holder consists of a shank *B* which fits the hole in the turret, and a holder *C* held to the body *B* by a screw, and located by a tongue and groove. The hole for screw *D* in holder *C* is larger than the body diameter of the screw, to provide for adjustment. The knurl which is shown detailed at *E* is provided with a shank which is a running fit in the

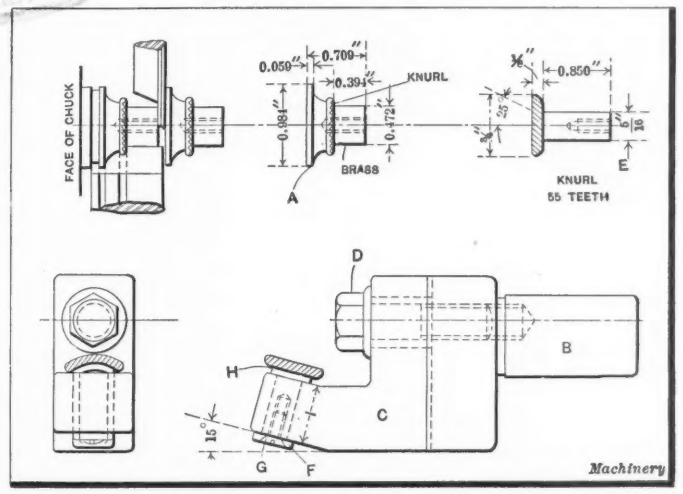


Fig. 3. End-knurling Tool held in Turret and operated at an Angle

hole in holder *C*. It is retained by a washer *F* and screw *G* and rotates on a hardened washer *H*. The distance *I* on the knurl shank is slightly greater than the width of the holder, so as to allow the knurl and washer *G* to rotate freely.

The knurl *B* and the knurl holder *D*, shown in Fig. 4, are

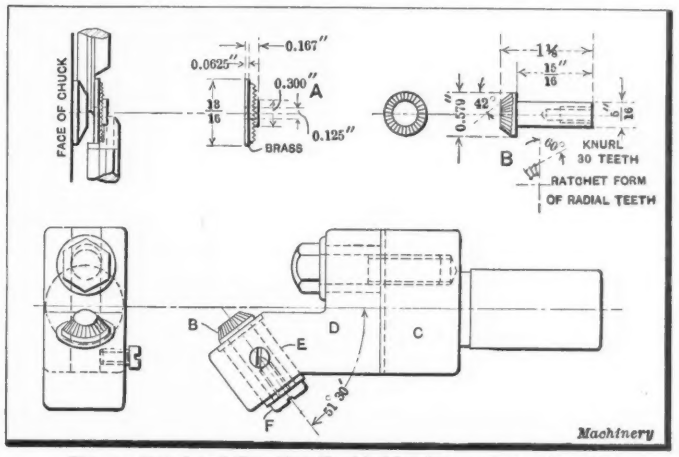


Fig. 4. Knurl and Knurling Tool-holder for producing Ratchet Form of Radial Teeth

used to produce a ratchet form of radial teeth in the shoulder of the piece shown at *A*, and also at *C* in Fig. 1. The teeth in the knurl are cut at an angle of 60 degrees and are radial with the center line. The work is rotated at 1216 R. P. M.,

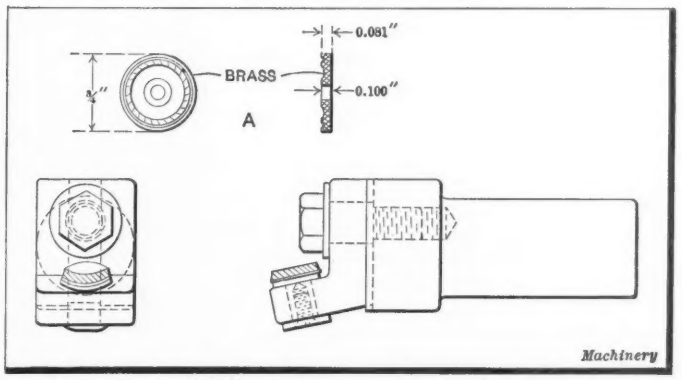


Fig. 5. Knurl and Holder for producing "Tangential" Form of Knurl

and a feed of 0.0008 inch is given to the knurl per revolution of the work.

This holder is held in the turret of a No. 2 Brown & Sharpe automatic screw machine, and consists of a body and shank *C* to which the holder *D* is held by a screw. The knurl *B* ro-

* See MACHINERY, June and July, 1909, "Knurls and Knurling Operations."

† Associate Editor of MACHINERY.

tates in a phosphor-bronze bushing *E* which is prevented from turning by a screw. The knurl is retained in the bushing by a large-headed screw *F* provided with a shoulder. There is sufficient end play to allow the knurl to rotate freely. It

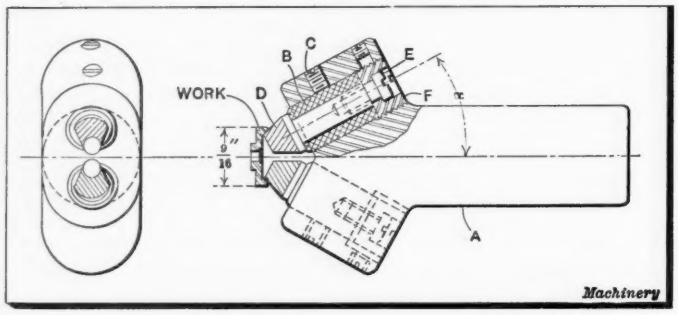


Fig. 6. Special Knurls and Holder for Internal Bevel Knurling

should be noted that in presenting the knurl to the work, the bottom of the teeth should be at right angles to the center line of the work holder.

A knurl holder having a marked similarity to that shown

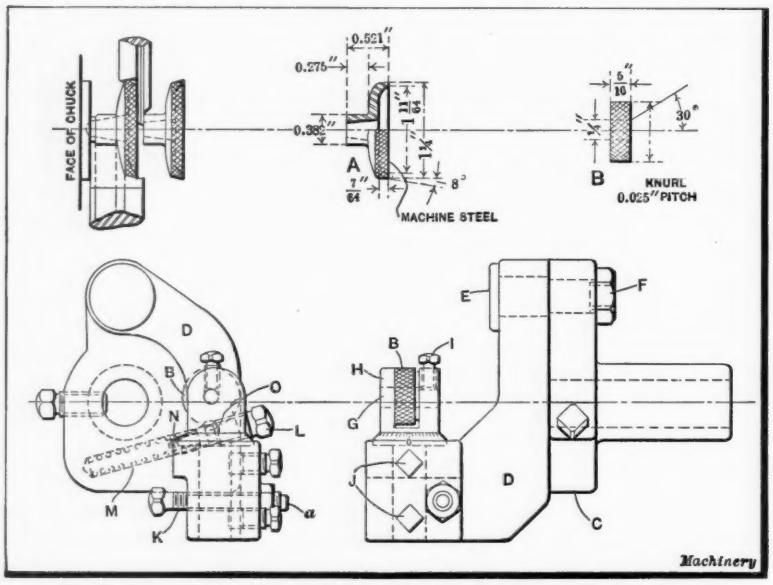


Fig. 7. Swing Type of Turret Knurl-holder for knurling at Various Angles

in Fig. 4 is illustrated in Fig. 5. In this case, however, the knurl is used for producing "tangential" teeth, as shown on the piece *B*, Fig. 1, and consequently it is provided with spiral teeth. It is not inclined at so small an angle with the center line of the holder, and approaches, when in operation on the work, as closely as conditions will permit, the action of a helical gear in mesh.

Internal Turret Knurl Holder

A special application of two bevel spiral knurls to the work is shown in Fig. 6. Here the portion of the work to be knurled is beveled at an included angle of approximately 90 degrees, and as shown at *A* in Fig. 1, a diamond-shaped knurl is to be produced. This operation can be more easily accomplished in this case with two spiral knurls than would be possible with one diamond knurl. Under these conditions it is advisable to have the angle *a* slightly less than half the angle on the work, so that it will be possible to use a bevel knurl, as a straight knurl would not work freely when operated from either the turret or cross-slide.

The holder *A*, Fig. 6, which is held in the turret, is made from a machine-steel forging and has two lugs, bored to receive the phosphor-bronze bushings *B*, these being retained in the holder by screws *C*. The knurls *D* are provided with shanks and are retained in bushings *B* by screws *E*, which rotate with the knurls. The end thrust of the knurls in this holder is considerable, so that it is necessary to back up the bushings *B* with screws *F*.

Special Swing Knurl Holder

A special knurl holder which is held in the turret and operated from the cross-slide by a rising block under the front tool-post, is shown in Fig. 7. The work is shown at *A*, and also at *D* in Fig. 1. It will be noticed that the work is considerably greater in diameter than that suited to the ordinary capacity of the No. 2 Brown & Sharpe automatic screw machine, thus requiring the use of a special outside feeding attachment, the ordinary feed tube being removed. The work is revolved at 240 R. P. M., and the knurl holder advanced at the rate of 0.00077 inch per revolution of the work. This is the speed at which the swinging arm *D* is moved, so that the actual feed of the knurl will be somewhat less than this amount.

The main body of holder *C* is provided with a shank held in the turret, and the swinging member *D* is held to its front face by a bolt *E* and nut *F*. The knurl *B* is held on pin *G* retained in the swivel holder *H* by screw *I*. The holder *H* is provided with angular graduations reading to degrees, so that the knurl can be set to the desired angle with the work. In the illustration the knurl is set straight, but in actual operation it is set around at an angle of 8 degrees. The shank of holder *H* is retained in the swinging member *D* by two set-screws *J*, which operate on bronze shoes to prevent marring the shank.

In operation, the rising block on the cross-slide comes in contact with the point *a* of the adjusting screw *K*, forcing the knurl into the work. The swinging member is returned to adjustable stop-screw *L* by a spring *M*, plunger *N* and pin *O*, the latter being driven into the swinging member and operating in an elongated hole in the holder *C*.

Special Opening Knurl Holder

An opening type of knurl holder is shown in Fig. 8. Two bevel knurls *B* are held in the swinging arms *C* and *D* in the manner shown in the sectional view. These arms are provided with offset lugs bored to receive the phosphor-bronze bushings *E*, which are prevented from turning by set-screws *F*. The knurls *B* are provided with shanks and are retained in the bronze bushings by screws *G*. The type of holder shown gives better results on the piece shown at *A*, and also at *E* in Fig. 1, than would a holder held on the cross-slide which would force the knurl straight into the work. The reason for this is that in operating a bevel knurl from the cross-slide on a tapered piece of work, the knurl has a tendency to glide off and produce an imperfect form of knurl. The opening type of holder obviates this difficulty to a considerable extent, as the power can be applied, so to speak, at right angles to the surface

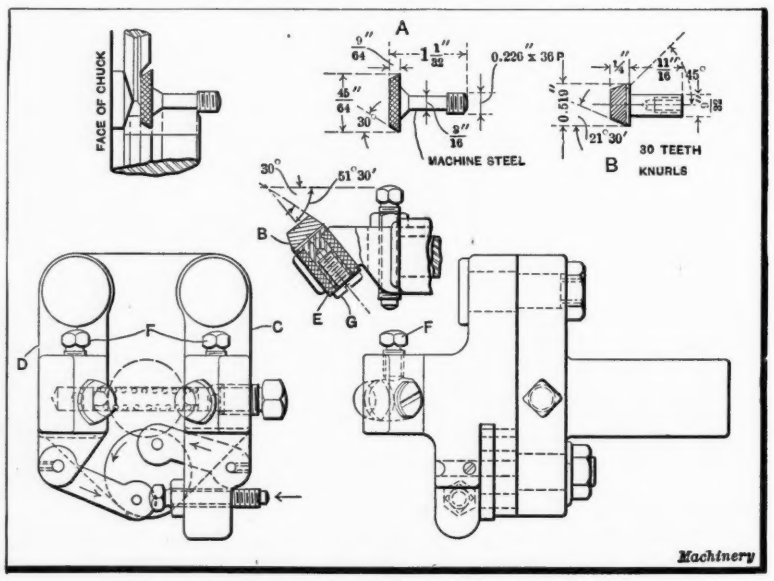


Fig. 8. Opening Type of Turret Knurl-holder for Bevel Knurling

knurled. The knurls are brought into position by the turret, and then fed into the work by the rising block on the cross-slide.

SPIRAL GEAR DESIGN*†—1

TO CALCULATE THE ELEMENTS OF FORTY-FIVE DEGREE COMBINATIONS

BY JAMES H. CARVER‡

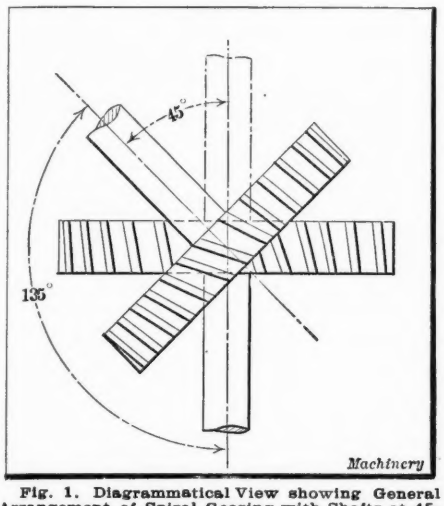
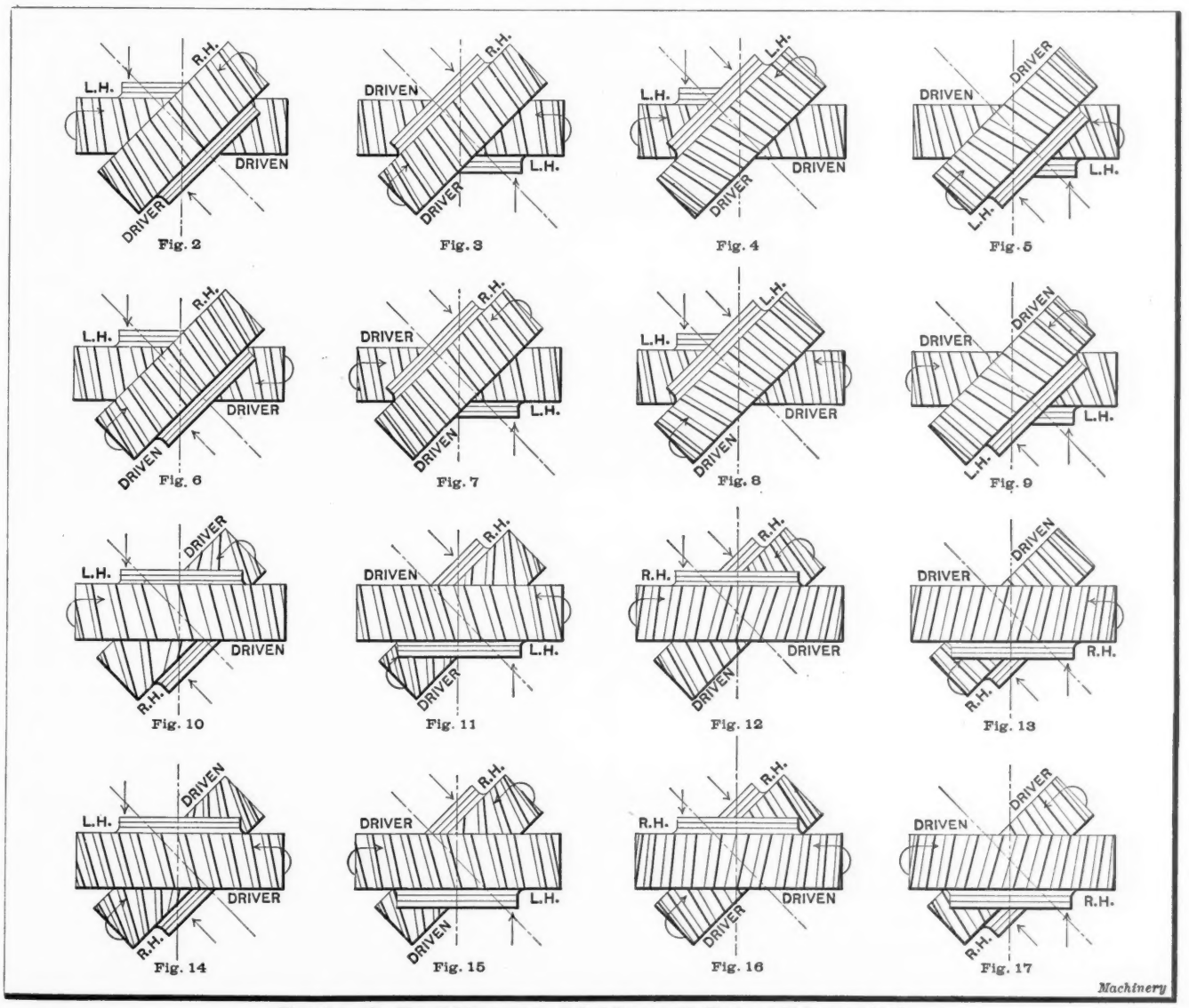


Fig. 1. Diagrammatical View showing General Arrangement of Spiral Gearing with Shafts at 45-degrees Angle

In the September, 1911, number of MACHINERY, the design of spiral gears with parallel shafts was dealt with, and in the October, 1911, number, spiral gears with shafts at right angles were treated. In the present article and in the accompanying Data Sheet Supplement, formulas will be given for calculating spiral gears with a shaft angle of 45 degrees. As seen in Fig. 1, the treatment, as far as the design is concerned, will be the same for a 135-degree shaft angle as for an angle of 45 degrees. Thrust diagrams Figs. 2 to 17 are given, the same as in the previous articles referred to, as an aid in determining the directions of thrust and rotation, and the direction of spiral, whether right- or left-hand. The arrows shown indicate the direction of the reaction against the thrust caused by the tooth pressure.

The relation between the direction of rotation, direction of spiral and spiral angle may be studied in Figs. 18 and 19. In Fig. 18 two spiral gears are shown, one in front of the other, with shafts at an angle of 45 degrees to each other. Line *AB* represents a right-hand spiral tooth on the front side of gear *C*. Assume gear *C* to rotate in the direction shown; then when the tooth *AB* reaches the rear side, it will be represented by line *EF*, which also represents the tooth direction on the front side of gear *G*. Angle *BOH* equals angle *EOH*, and it will be seen directly that the spiral angle of either gear equals 45 degrees minus the spiral angle of the other, both gears being right-hand. In Fig. 19 the spiral angles are shown to be of opposite hand, and one spiral angle is 45 degrees plus the other angle. From these illustrations we may draw the following conclusions relative to gears with a shaft angle of 45 degrees:

When the spiral angle of either gear is less than 45 degrees, then the spiral angles are the same hand, and one spiral angle is 45 degrees minus the other. When the spiral angle of either gear is greater than 45 degrees, then the spiral angles are of opposite hand, and the spiral angle of one gear is 45 degrees plus the spiral angle of the other.



Figs. 2 to 17. Thrust Diagrams for Spiral Gears with Shafts at 45-degrees Angle

The four cases which are dealt with in the accompanying Data Sheet Supplement are:

1. Shafts at 45-degrees angle, ratio equal and center distance approximate. 2. Shafts at 45-degrees angle, ratio equal

* With Data Sheet Supplement.

† See "Spiral Gear Design", MACHINERY, September, 1911, engineering edition, and the articles there referred to. See also MACHINERY'S Reference Book, No. 20, "Spiral Gearing", and MACHINERY'S Data Sheet Book, No. 6, "Bevel, Spiral and Worm Gearing".

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and center distance exact. 3. Shafts at 45-degrees angle, ratio unequal and center distance approximate. 4. Shafts at 45-degrees angle, ratio unequal and center distance exact.

The Data Sheet Supplement gives the required formulas for calculating gears for each of these cases. In the following the derivation of some of these formulas is explained.

1. Shafts at 45-degrees Angle, Ratio Equal, and Center Distance Approximate

As already stated, the spiral angle of one gear must equal 45 degrees plus or minus the spiral angle of the other. The formulas in the Supplement in Part (*a*) are to be used when the spiral angles of both gears are 22½ degrees, which will often be the case. The pitch diameter of both gears will be equal, and are found by the formula (see Data Sheet Supplement for notation):

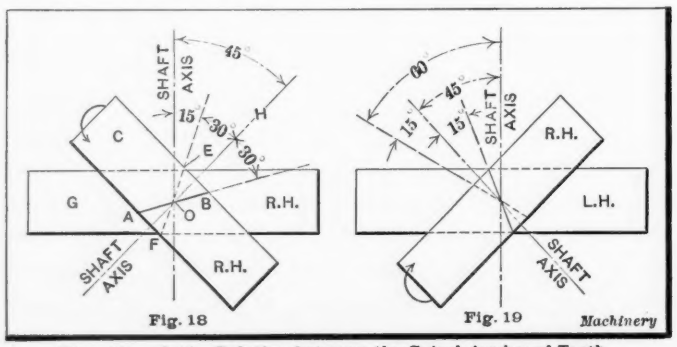
$$D = \frac{N}{P_n \cos 22\tfrac{1}{2}^\circ} = \frac{N}{0.92388\ P_n}$$

Further

$$T = \frac{N}{\cos^3 22\tfrac{1}{2}^\circ} = \frac{N}{0\ 788}$$

$$L = \pi\ D \cot 22\tfrac{1}{2}^\circ = 7.584\ D$$

The other formulas are the same as those given in the arti-



Figs. 18 and 19. Relation between the Spiral Angles of Teeth in Two Gears

cles referred to at the beginning of this article. Part (*b*) is used for unequal spiral angles.

2. Shafts at 45-degrees Angle, Ratio Equal, and Center Distance Exact

Following the same method of reasoning as in Case (6), "Spiral Gear Design", MACHINERY, October, 1911, the approximate number of teeth in each gear is found from the equation:

$$\frac{N}{P_n \cos \alpha_a} + \frac{N}{P_n \cos \beta_a} = 2\ C$$

from which, multiplying by $P_n \cos \alpha_a \cos \beta_a$,

$$N \cos \beta_a + N \cos \alpha_a = 2\ C P_n \cos \alpha_a \cos \beta_a, \text{ or}$$

$$N = \frac{2\ C P_n \cos \alpha_a \cos \beta_a}{\cos \beta_a + \cos \alpha_a}$$

After the exact number of teeth to be used in each gear is found from the last equation, the spiral angles are found from the same equation used in finding the approximate number of teeth.

Let $\dfrac{N}{P_n \cos \alpha} + \dfrac{N}{P_n \cos \beta} = 2\ C$, where α and β are now the exact spiral angles. The secant being the reciprocal of the cosine,

$$\frac{N}{P_n} \sec \alpha + \frac{N}{P_n} \sec \beta = 2\ C, \text{ or } \sec \alpha + \sec \beta = \frac{2\ C P_n}{N}$$

By using a table of secants, reading to minutes, angles can be found to satisfy this equation, after very few trials.

3. Shafts at 45-degrees Angle, Ratio Unequal and Center Distance Approximate

A formula for finding the number of teeth in the small gear is found from the equation:

$$\frac{N}{P_n \cos \alpha} + \frac{n}{P_n \cos \beta} = 2\ C$$

by solving for the value of n, the relation of N to n being:

$$R = \frac{N}{n}, \text{ or } N = Rn$$

Then multiplying by $P_n \cos \alpha \cos \beta$, we have:

$$N \cos \beta + n \cos \alpha = 2\ C P_n \cos \alpha \cos \beta$$

and substituting Rn for N:

$$n = \frac{2\ C P_n \cos \alpha \cos \beta}{R \cos \beta + \cos \alpha}$$

After finding the number of teeth N from the relation $Rn = N$, the pitch diameters are found in the manner previously described. In Part (*a*) are given the formulas to be used when both spiral angles are 22½ degrees. The constants were found from the numerical values of the functions in the formulas of Part (*b*), which latter formulas are used for unequal spiral angles in the two gears.

4. Shafts at 45-degrees Angle, Ratio Unequal, and Center Distance Exact

This case could be used under the same conditions spoken of in Case (8), "Spiral Gear Design", MACHINERY, October, 1911. The number of teeth is found exactly as in Case (3) of the present article, after which the exact spiral angles are found by trial from the equation:

$$R \sec \alpha + \sec \beta = \frac{2\ C P_n}{n}$$

which is found from the equations

$$\frac{N}{P_n \cos \alpha} + \frac{n}{P_n \cos \beta} = 2\ C, \text{ and } N = Rn$$

in the same manner as before. When using these equations for finding spiral angles, the table used must give values to minutes in order to insure accuracy.

* * *

HOW TO PATCH A CONCRETE FLOOR

When a cement floor surface becomes worn, it is often necessary to patch it. Mr. Leonard C. Wason, president of the Aberthaw Construction Co., Boston, in a recent paper describes the common, or wrong way, and the right way, as follows:

Commonly a sand and cement mortar is made, some cutting is done and the mortar is put in and scrubbed with a steel trowel until smooth. It is then covered up for a while. If the concrete under the patch is left dry, it soaks up the water of the mortar. As a result, the mortar does not set. If the room is dry or hot the surface of the patch dries out and for the same reason it does not set. If the concrete under the patch is dusty the patch does not adhere to the concrete. If the materials in the mortar are not suitable, naturally the patch wears badly, particularly as it is obviously located at a point of severe wear.

To proceed in the right way, cut down the worn place at least one-and-a-half inch. This cutting should be carried into the strong unbroken concrete and the edges should be cleanly undercut. The bottom of the cut should then be swept out, clean-blown out with compressed air or a pair of bellows, if available, then thoroughly wet and scrubbed with a broom. In this way, small loose particles of broken material which the chisel has driven into the surface are removed. A grout made of pure cement and water, about the consistency of thin cream, should be scrubbed into the pores with a broom or brush, both at the bottom and sides of the cut. Following this a stiffer grout, about the consistency of soft putty, should be thoroughly compressed and worked into the surface, which has already been spread with grout. Finally, before the grout is set a mortar made of one part cement to one part crushed stone or gravel, consisting of graded sizes from one-half inch down to the smallest, excluding dust, should be thoroughly mixed and put in place, then floated to a proper surface. Cover with wet bagging, wet sand, sawdust or other available material. All trucking should be kept off and the surface kept thoroughly wet for at least one week or ten days.

If a particularly hard surface is required, six-penny nails are sometimes mixed with the mortar and other nails stuck into the surface when the patch is finished. This will produce a surface which is extremely hard and durable.

* * *

When a man thinks that he is too old to learn, it simply means that he is getting either too self-satisfied or too stubborn and contrary, for there is no age limit to learning.

MAKING ANNULAR BEARINGS*

SOME OF THE MACHINERY AND METHODS EMPLOYED IN THE MANUFACTURE

BY ROBERT H. GRANT†

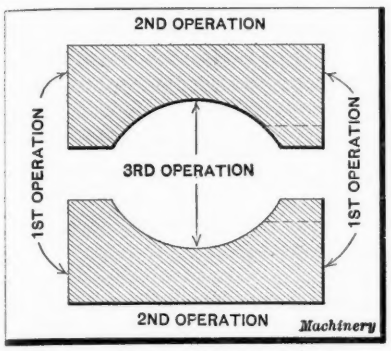


Fig. 1. Order of Grinding Operations on Races

The rapid increase in the use of annular ball bearings has led to many improvements in their design. Such improvements have required a corresponding development in the methods used in the manufacture of these bearings, until they have now reached a very complete stage. The inner and outer races were formerly made from separate pieces of bar stock and this method was responsible for a waste of at least eighty per cent of the raw material. This operation was improved by the writer so that both races were produced from the same bar, as described in a previous article in MACHINERY.

Use of Drawn Tubing

The next development in the production of the races came in the form of the tubing made by the Becker Steel Co., New York City. The smaller sized races can now be made very rapidly from this stock, using an automatic screw machine. The larger sizes are produced on Fay automatic lathes of the type made by the Jones & Lamson Machine Co., Springfield, Vt. In making the larger sized races, tubing or forgings of suitable size and material are used. The Fay automatic lathe shown in Fig. 2 has a worm-driven head which gives ample power for driving several tools at a time. The turning and facing tools are worked together, and the rounding of the corners is done by the same facing tools. The bar used for boring the races has two sets of tools inserted in it, the finishing tool starting right after the roughing tool has gone through the ring. Owing to the semi-automatic action of the machine, it is possible for one man to run four machines, thereby reducing the cost of machining to a minimum.

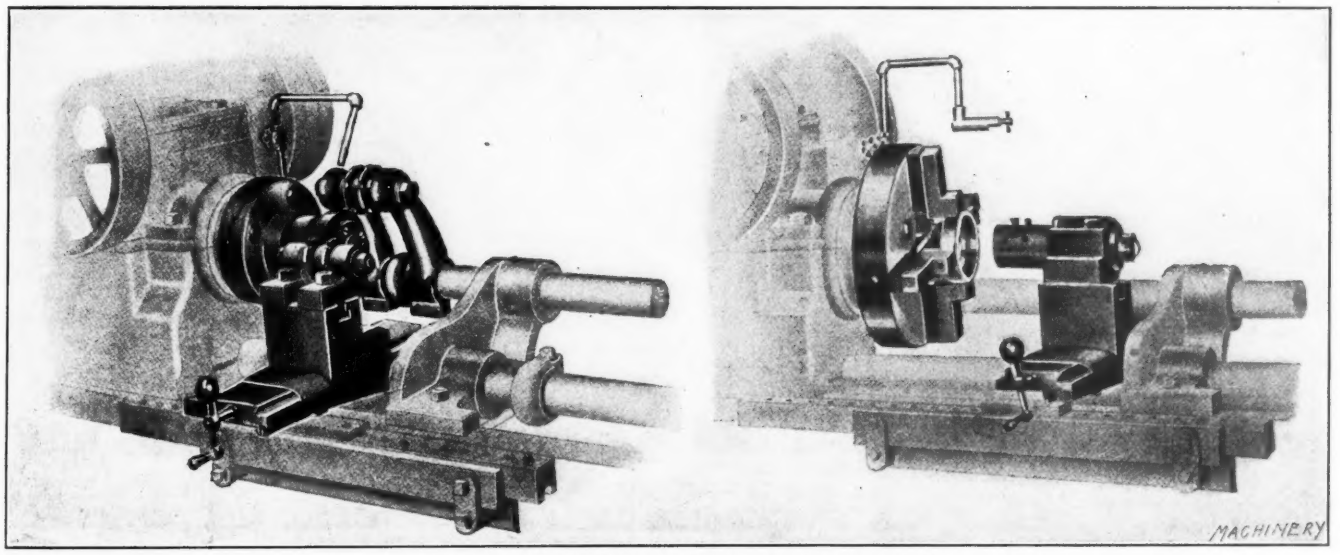


Fig. 2. Fay Automatic Lathe used for forming Blanks for Races

Hardening and Grinding

The extreme thinness of the bearing races makes it difficult for them to hold their shape. Consequently they must be very carefully treated in the hardening department. The method of procedure followed in the hardening operation was fully dealt with in a previous article in MACHINERY. After being hardened, the work is ready for grinding, the order of the operations being shown diagrammatically in Fig. 1. The first grinding operation, which consists of roughing out the blanks, has the effect of relieving the strains in the work. This important operation is performed on a Pratt & Whitney or a Blanchard face grinder. The work is held in a magnetic chuck so that a number of races can be ground at a time and still maintain the required degree of accuracy. The outer races are next mounted on a gang-arbor, as shown in Fig. 3; this arbor is considerably smaller than the hole in the work, the size being indicated in the illustration. A simple method of loading the arbor consists of having a V-block to support the work, and adjustable V-blocks that support the arbor at each end. These blocks are set in such a position that the work is centrally located on the arbor when the clamping nut is tightened. The work is now ready to be ground on the outside. The outside of the inner races is ground in the same way. The hole in the inner races is also ground in a gang fixture, as shown in Fig. 4. This will be seen to consist of a sleeve of the proper size to hold the work, which is secured between the shoulder at one end and a threaded cap at the other. When the sleeve has been loaded with work, it is held in a universal chuck. This method of grinding has effected a considerable reduction in the cost of manufacturing. The grooves in both the inner and outer races are rough-ground with a form wheel. After grinding, the work is allowed to

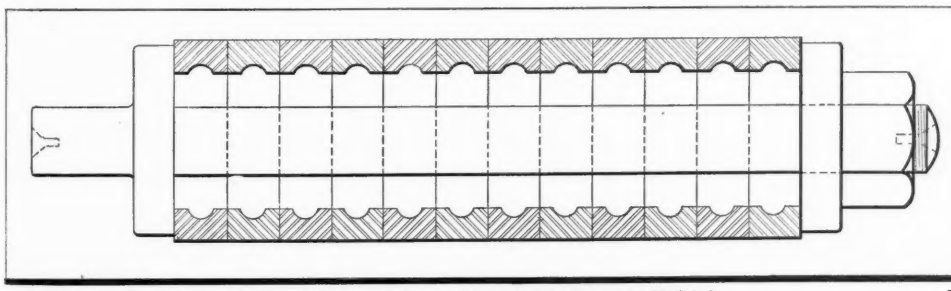


Fig. 3. Arbor used for grinding Outer Races in Multiple

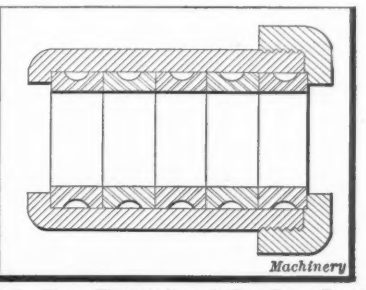


Fig. 4. Gang Fixture for grinding Inner Races

* For additional information on the manufacture of ball bearings, see article entitled "The Manufacture of Steel Balls" published in MACHINERY for February, March and April, 1912; also article entitled "Ball and Roller Thrust Bearings" published in August, 1912, and other articles there referred to.

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"rest" for two or three weeks, after which time it is ready for finishing. The high finish which is produced on the ball bearings of foreign manufacture has made it necessary for the American product to be brought to corresponding perfection in order to compete in the open market.

The grinding of the grooves in the races is, of course, one of the most important steps in manufacturing ball bearings.

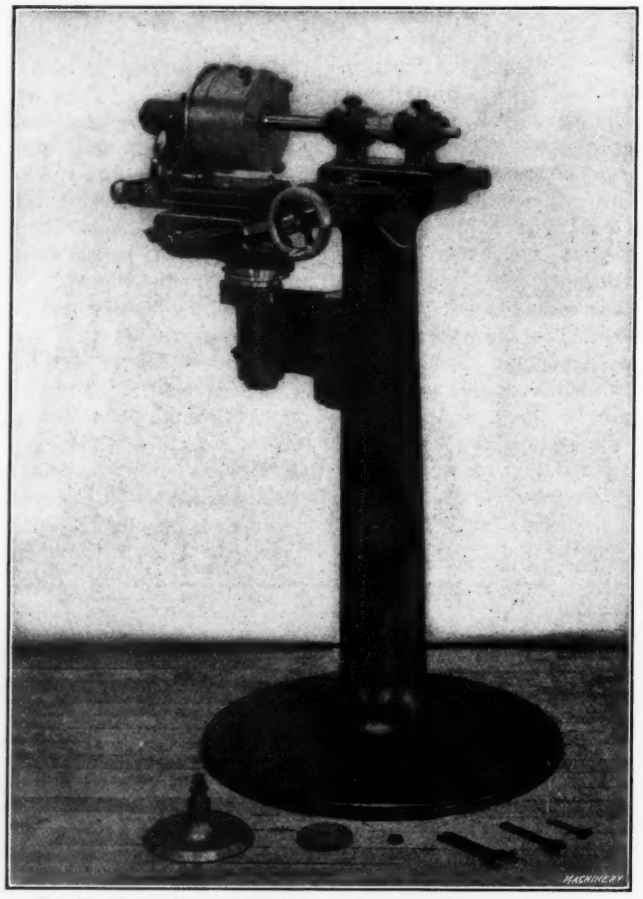


Fig. 5. Simple Form of Machine for grinding Grooves in Races

The machinery for doing this grinding has seen a great many improvements, and has now been brought to a stage where it is well nigh perfect. Fig. 5 shows the original type of grinder made for the trade by the Brown & Sharpe Mfg. Co., Providence, R. I. This was a very simple head that was mounted on one of the bases of the B. & S. No. 2 cutter grinder; the machine had a special head so that it could be used for radius grinding on both the inner and outer races. The column of the machine has a bracket attached to it, which is provided with a vertical adjustment and bored out to receive the grinder head that is equipped with two slides, thus providing for adjustment in two directions. The lower slide has a scale graduated on it, and a pointer is screwed to the bracket; this provides for setting the head over so that any radius can be ground, as the center of the wheel and the center of the bracket are kept in a direct line. The upper slide carries the work spindle and has a rack and pinion arrangement which provides for moving the head back from the wheel, so that the work can be measured at any time without disturbing the adjustment. This slide is also provided with an adjusting screw; in case the work which is carried in the spindle gets out of line with the wheel, it can be adjusted very easily. The work head has a pulley attached to it and is driven from the countershaft at constant speed. The slide which carries the wheel head is fastened to the base, and is equipped with stop pins that control the length of movement. The spindle runs in phosphor-bronze bearings, which are arranged with the usual form of take-ups so that they always fit closely. The drive is provided by two-step cones, to which a belt runs direct from the countershaft.

At the time of receiving our order, the Brown & Sharpe Mfg. Co. was so busy that it was unable to make us more than five of these machines, but the company lent us the patterns and sold us all the standard parts so that we were able to build these grinders in our own factory. The oscillatory motion of the head on this type of grinder was produced by hand and made it necessary to assign one man to operate each machine. This suggested the possibility of improvement by providing means for securing the oscillatory movement by power. The method by which this was finally accomplished, is shown in Figs. 6 and 7, where it will be seen that a bracket is attached to the column of the machine about 18 inches from the floor. This bracket carries a worm and worm-wheel, which are driven by a three-step cone pulley. A plate is mounted at the top of the worm-wheel spindle; this plate has a T-slot cut through its face so that the driving rod, which connects with the grinder head and produces the oscillatory motion, can be set at different distances off center. This provides for giving the work head any amount of throw which is necessary to grind the grooves in the races. The transmission of power from the plate on the worm-shaft to the grinder head is effected by a rack which is cut in the end of the connecting-rod. The teeth of this rack drive a suitable spur gear which is a loose fit on a shaft that is part of the lower work head slide. A plate is keyed to the shaft above this gear and carries a plunger that can be raised or lowered by a lever. When it is required to throw in the drive, this lever brings the plunger down into a hole in the spur gear and starts the head oscillating. Fig. 7 shows a machine of this type, and by referring to this illustration, together with the line drawing, the method by which the head is oscillated will be readily understood.

Holding the Races for Grinding

The next important advance which was made in the design of machinery for grinding the races of annular bearings consisted of an improvement in the method of holding the work. Formerly, the work was held in the head by means of a split ring and adjusting screws. These screws were manipulated to locate the work in the desired position; this was a very tiresome job, as it frequently took from five to eight minutes

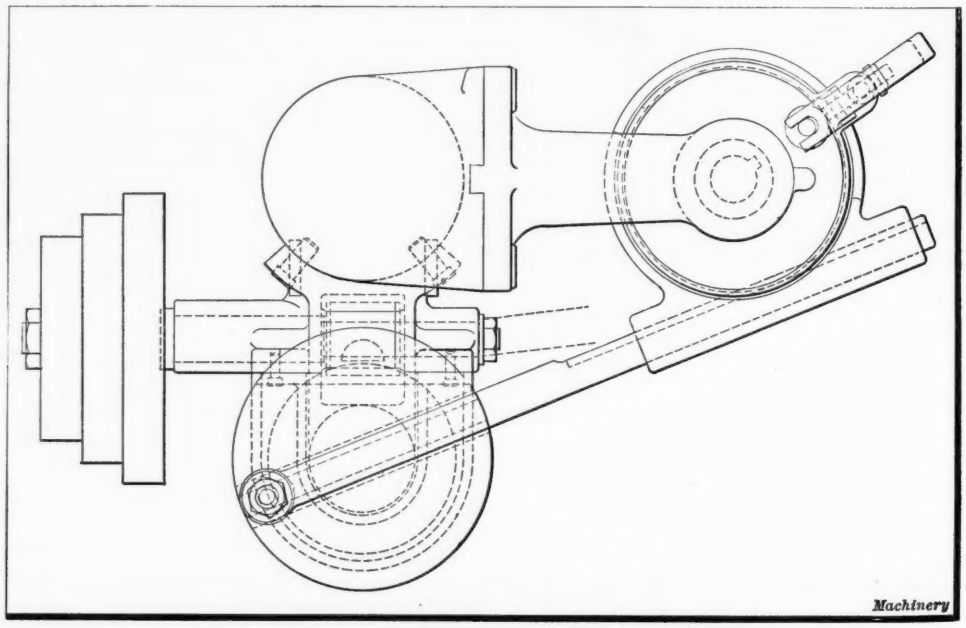


Fig. 6. Mechanism of Power Drive for oscillating Grinder Head

to get the races in a central position. Fig. 8 shows the improved method, which consists of taking the same head and inserting a hardened steel ring that is tapered on the inside. A master chuck was made to fit this taper and pads were then made to fit any race, the construction being similar to that used in an ordinary screw machine. A hole was drilled

through the spindle to carry the drawback bar, which is fitted with a knob at the outer end that is turned to open or close the chuck by hand. The chuck is prevented from turning, while the work is being put in or taken out, by means of a pin which is carried in the grinder head. As it was not necessary to grind the races to one diameter on the outside, the variation allowed the center of the work to come out of center with the emery wheel. To avoid this trouble, three stop-pins

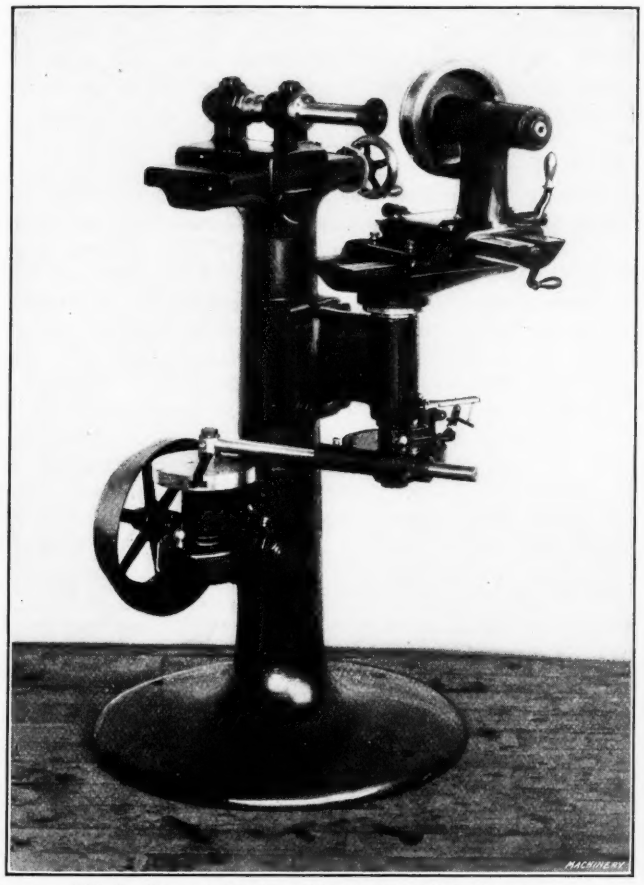


Fig. 7. Type of Machine with Head oscillated by Power

were arranged on the inside of the chuck, the pins being fastened to the head. This allowed the race to come against the pins while the chuck was being closed, thereby holding it central with the emery wheel.

Wet Grinding the Ball Races

Up to this time we had been using a dry wheel, which of course made the work very slow. In order to increase production, the problem of equipping the machines to use a wet wheel was next undertaken, and a solution was finally found in equipping the machines with water guards. It will be

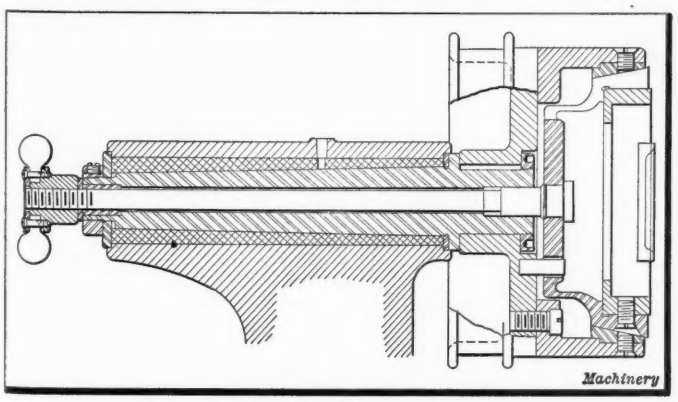


Fig. 8. Improved Type of Grinder Head Chuck

readily understood that this was not an easy matter, as the oscillation of the head caused the water to be thrown in all directions. Fig. 9 illustrates a machine equipped with water guards of the type that was finally devised. The application of wet grinding created a material increase in the amount of work produced. Further increase in this direction arose from equipping the machine with a power feed for the wheel head; this made it possible for one man to run four machines and still produce a very fine grade of work. The power feed for the wheel head was accomplished by means of a regular ratchet wheel and a friction disk which allowed the emery wheel to be fed into the work to a certain point and then stop at any place at which the stop on the friction disk had been set.

The process of grinding the intake groove that is used for assembling the balls in the races requires a great deal of care. This groove must not be too deep or it will permit the balls to jump and catch; if it is too shallow, it will cause the races to be sprung out of shape during the assembling process. The emery wheel used for grinding this groove is slightly larger than the diameter of the balls used in the size of annular bearing race being ground. The depth of the groove is determined by the use of a ball-point micrometer caliper, with which the distance between the bottom of the groove and the outside diameter of the race is measured.

The final operation before assembling consists of polishing or lapping the work. American manufacturers have been considerably behind their European competitors in regard to their polishing methods; it has been the custom to polish only the grooves of bearings made in America, whereas the foreign

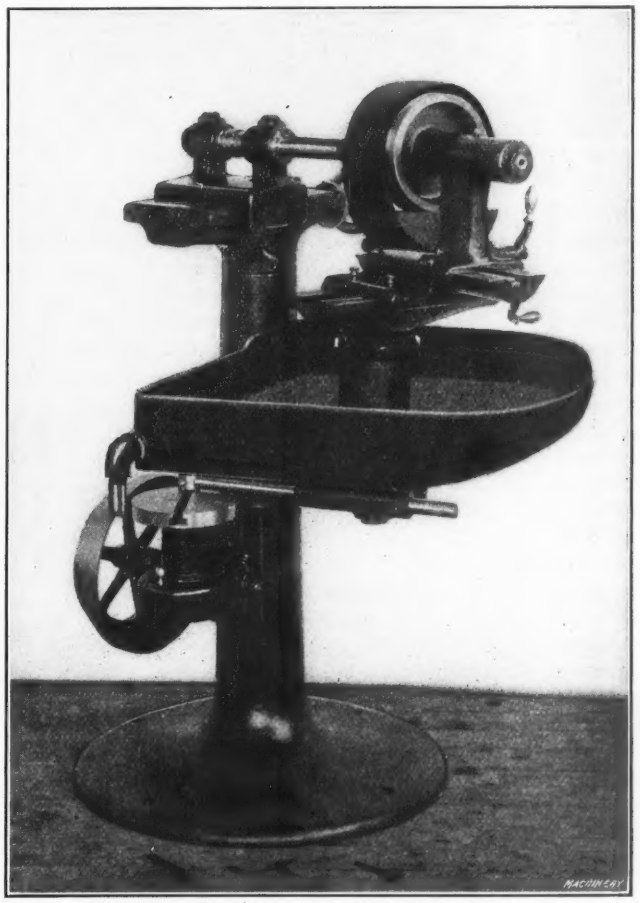


Fig. 9. Type of Water Guards used for Wet Grinding

manufacturer laps the entire surface of the bearing. The finishing operation is conducted by remounting the work in the grinder and using a hard wood wheel covered with crocus, going through the same operation as was formerly followed in grinding the bearing from the rough.

Assembling Bearings

The method of assembling this type of annular ball bearings is a very simple matter. Fig. 10 shows a view in the assembling room which is equipped with tables upon which cast-iron surface plates are mounted. These plates are provided with auxiliary plates of tool steel, which are first hardened and then carefully ground to a perfect surface. Five boxes are located at the rear of each assembling table and each of these boxes contains balls of different sizes. These sizes are as follows: O. K., 0.0005 inch large, 0.0005 inch small, 0.001 inch large, and 0.001 inch small. In assembling a bearing, the assembler takes three balls from one of these boxes and forces them into the bearing by means of the arbor press which is fastened to the table. He then distributes these

balls around the bearing and tests it for the closeness of fit. If the bearing is either too loose or too tight, he forces the balls out and replaces them with the next larger or smaller size, according to the fit that was produced with the first balls tried. This process is repeated if necessary, until the proper size has been secured; the bearing is then filled with balls if it is of the full type, or with one less than the number required to fill the races if a cage is to be used. The foreign manufac-

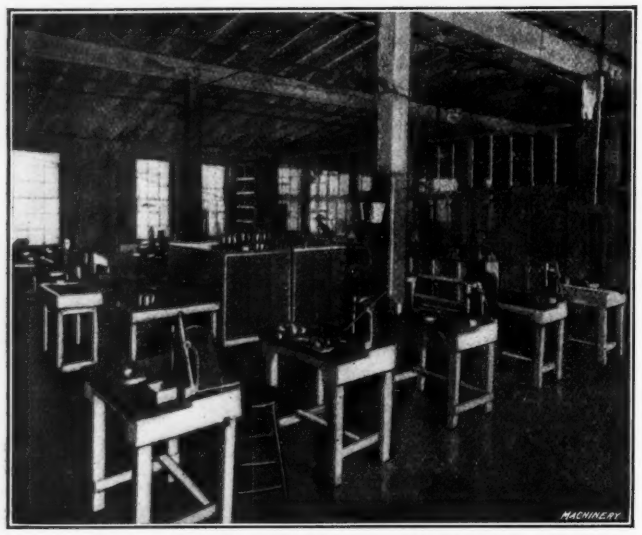


Fig. 10. Equipment of Room where Annular Bearings are assembled

turers grind all their bearings to one size and consequently they only require an O. K. ball. This is a more expensive process, and to reduce the cost of production American manufacturers have adopted the method previously described. After the assembling process is complete, the assembled bearing is subjected to a final grinding process in order to make the outside of the outer race concentric with the center. As the inner races are a trifle thinner than the outer races, the bearings can be assembled on a gang arbor in the same manner as shown in Fig. 3. In this case, the arbor is of the proper size to fit accurately in the hole in the inner races, and the side faces of the outer races bear against each other. The work is accurately located in this way, and when the grinding operation is finished, the outside of the races is concentric with the center, provided the assembling has been properly done. The finished bearings are tested and then marked to indicate their eccentricity and the degree of side motion that the outer race has when revolved on the inner race. The degree of accuracy required runs from 0.0005 inch to 0.0015 inch according to the diameter of the bearing.

* * *

Steel hardened in oil has not so hard a surface as when hardened in water. This is due to the fact that when water is used for quenching, the cooling of the heated steel takes place at a much more rapid rate than when the cooling is in oil. Experiments show that a piece of steel will cool from 700 to 600 degrees C. (from 1292 to 1112 degrees F.) in five seconds when quenched in pure water, while, when quenched in oil, forty-three seconds was required to cool off the same amount.

* * *

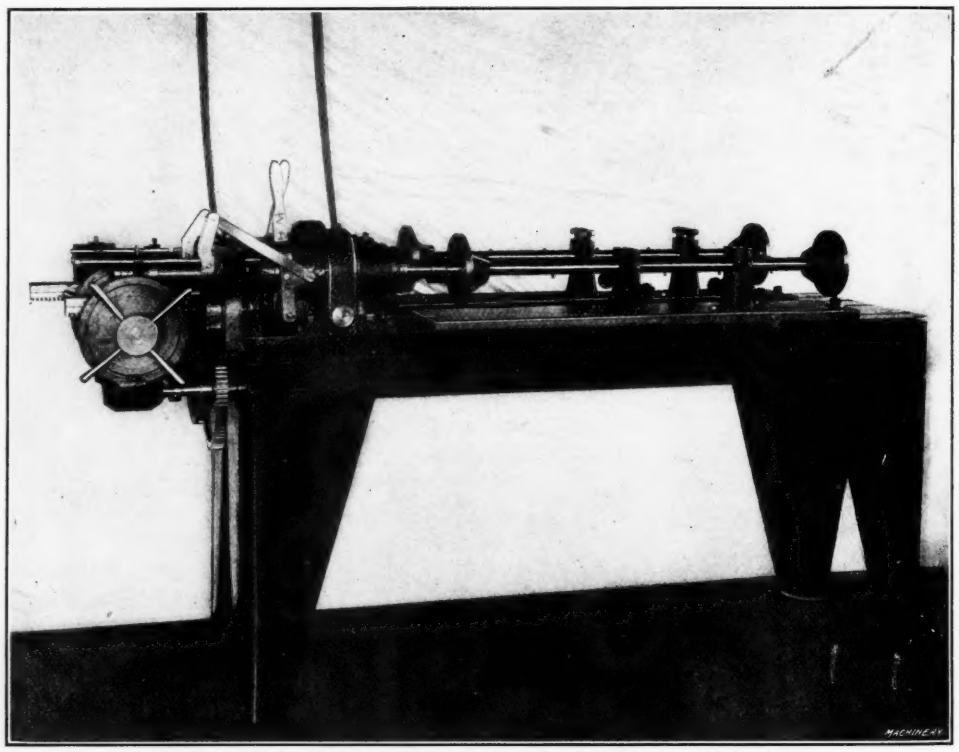
The motor boat *Baby Reliance III* is probably the fastest in the world, having a speed record of 53.8 miles per hour. She is driven by a twelve-cylinder Van Blerck engine fitted with Bosch magnetos.

A DOUBLE-SPINDLE CRANK-CASE BORING MACHINE

A double-spindle horizontal boring machine which will bore a crank-case in two and one-half minutes, when it formerly took fifteen minutes, has just been completed by the tool construction department of the H. H. Franklin Mfg. Co., Syracuse, N. Y. The machine bores two crank-cases at a time; each case has five crankshaft bearings, so that ten bearing holes can be bored at one setting. The operator adjusts one crank-case on the machine and starts boring. While the first crank-case is being bored he adjusts the second, and by the time it is ready, the first crank-case is finished. In this way, continuous operation is obtained.

It will be seen from the illustration that there is an auxiliary table for the different sizes of crank-cases. The work is clamped to the auxiliary table, and two pedestals steady the boring-bars in the center. There are heads at each end of the boring-bars which fit in the ends of the crank-cases, holding them in their true position and practically making each case its own aligning jig. Each boring-bar has five pairs of cutters, which reduce the size of the chips on each cut. These cutters can be adjusted to bore different sized bearings for the different sizes of crank-cases. They bore holes from 1½ inch to 2 inches in diameter.

The boring-bars are driven by a semi-universal joint from the main spindle of the machine. Each spindle is independent and has an independent control. The feed drive is similar to that on any other horizontal boring machine; both heads are driven by worm-wheels from one shaft which runs at 1100 revolutions per minute, and drives the boring-bars at 200 revolutions per minute with a feed of 0.005 inch per revolution. There is a clutch for each main drive and one for each feed; these clutches have an automatic knockout for stopping the spindle and feed. The feed on this machine is obtained by a rack and pinion operating through a train of gearing from the main spindles.



Double-spindle Machine for boring the Crank-cases of Franklin Motor Cars

The machine is designed for one speed and one feed. All bearings have solid bushings to prevent changes in the feed and speed, and to prevent the operator from needlessly adjusting the bearings and getting anything out of order. A safety device on the clutch keeps the spindle from starting unintentionally, thereby protecting the operator from injury while setting the bars or crank-case.

* * *

Good lockers for the men should be a part of the equipment of every modern shop and factory.

FORMS OF BABBITTING FIXTURES

BY JOHN A. H. PHILLIPS*

The work of babbitting bearings offers considerable opportunity for the use of different forms of fixtures that are capable of making a material increase in the efficiency with which this operation can be carried on. During the writer's experience, he has had occasion to babbitt a variety of bearings, and in the following article a description is given of the different types of fixtures which he has used.

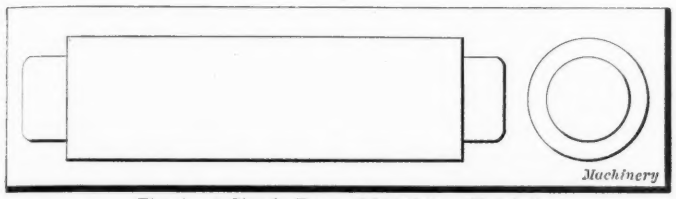


Fig. 1. A Simple Form of Babbitting Mandrel

Fig. 1 shows the most common of all forms of babbitting mandrels. This is merely a piece of shafting of the required size, which is turned down at the ends to fit into the corresponding hole in the supporting plate *A*, shown in Fig. 7. This plate is a piece of cast iron with a number of different sized holes bored in it to fit various sizes of mandrels. The body of the mandrel is turned with a taper of 0.0025 inch per foot of length in order to make it easy for the operator to remove it from the finished bearing. The mandrel is painted with a coat of thin white lead each time it is used.

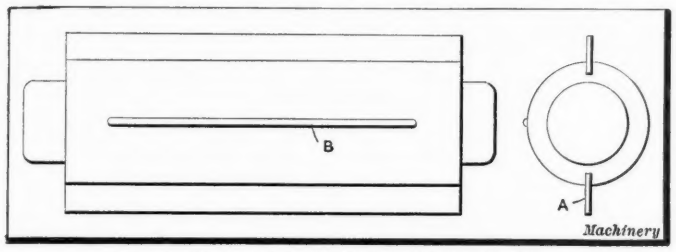


Fig. 2. Mandrel for babbitting Plain Bearing Caps

Fig. 2 shows an arbor for babbitting the cap of a plain bearing. Two thin pieces of steel *A* are inserted in this mandrel, and the space occupied by these strips while babbitting is replaced by liners in the finished bearing. *B* is a projection on the mandrel which forms the oil groove in the bearing, obviating the necessity of cutting it after the babbitting operation has been completed. The fixture shown in Fig. 7 is used for clamping the bearing to the mandrel.

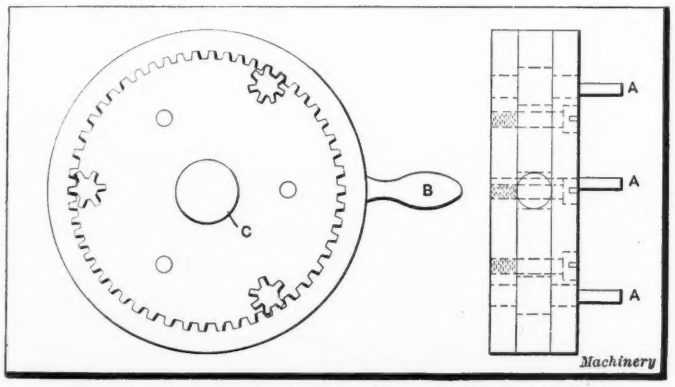


Fig. 3. Fixture used for locating Bearing at Center of Wheel

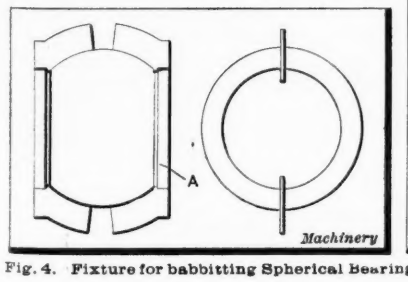


Fig. 4. Fixture for babbitting Spherical Bearings

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Fig. 6 shows a rather more complicated form of babbitting mandrel which is used for ring oiling bearings. The two rings *A* are attached to the mandrel and serve to give clearance for the oil rings in the cap. The two small rings *B* are not fastened to the mandrel but are placed in the bearing to prevent the babbitt from running out; the space around these rings is carefully plugged up with putty before the babbitt is poured. Bearings of this type must be babbitted in a horizontal position, the six notches cut in the sheet-steel feathers being used to provide space through which the babbitt is poured.

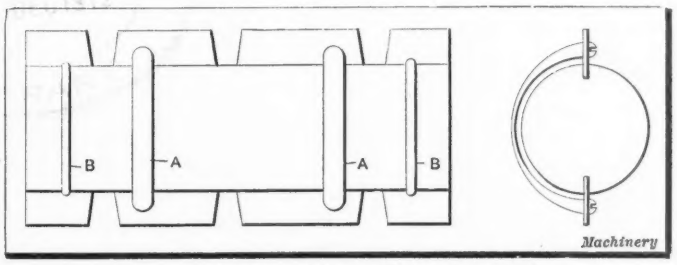

Fig. 6. Mandrel for babbitting Ring Oiling Bearings

Fig. 4 shows a fixture used for babbitting spherical bearings. In this case, the shoulders *A* are made to fit the castings as closely as possible, and any remaining cracks are carefully plugged with putty in order to prevent the escape of the babbitt. This type of bearing is babbitted in halves similarly to the ring oiling bearings, the babbitt being poured through the notches in the thin steel plates, as in the preceding case.

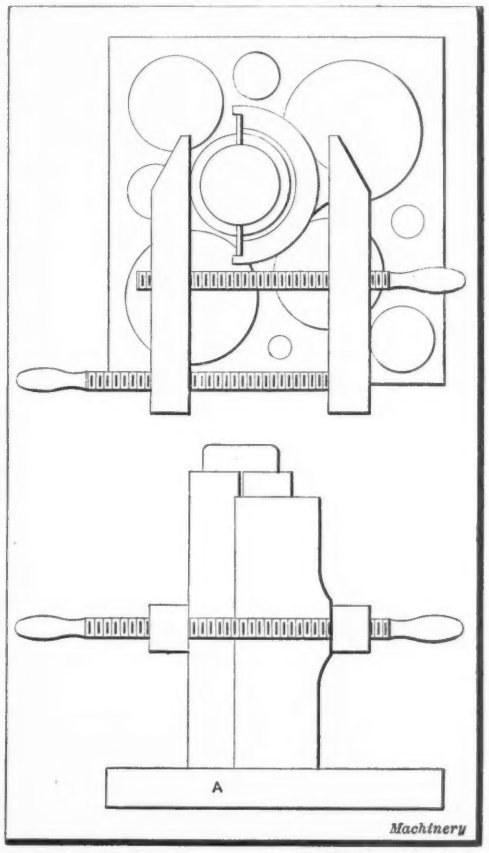

Fig. 7. Fixture for supporting Babbitting Mandrels

The mandrel shown at *A* in Fig. 5 is used for babbitting the bearing *B*, which is a type that is extensively used on belt conveyors used for handling a variety of loose materials.

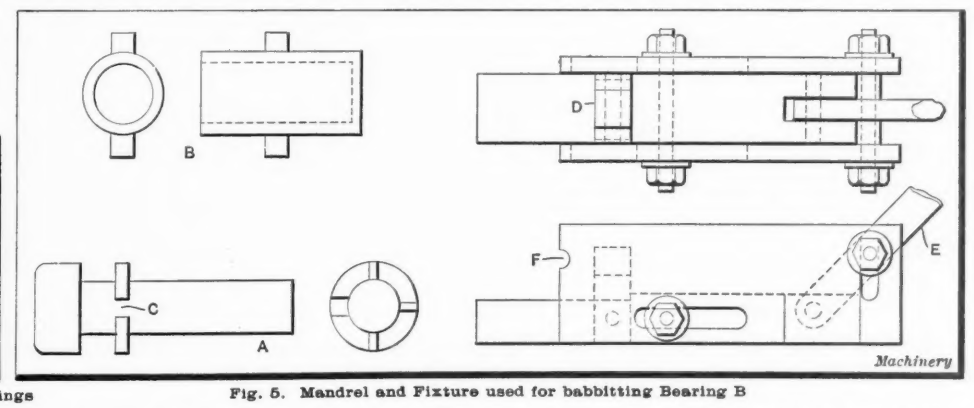

Fig. 5. Mandrel and Fixture used for babbitting Bearing B

The four notches *C* are used as sight holes for centering the mandrel in the bearing; one of these notches is cut larger than the others and is used for pouring the babbitt into the bearing. The jig shown at the right-hand side of the illustration is used for removing the bearing from the mandrel. The

mandrel is placed in the slot *D* with the bearing projecting, and when the lever *E* is brought forward, the notches *F* come into contact with the lugs on the bearing and force it off the mandrel.

Fig. 3 shows a fixture for babbitting cast-iron rollers and wheels. This fixture was designed to provide a means of locating the bearing in the exact center of a wheel; it is made in two halves with teeth cut on the inside of the ring as shown. The three pins *A* are turned eccentric with the pinions of which they are a part, and by swinging the handle *B*, the wheel is accurately centered. A mandrel of the type shown in Fig. 1 is used in connection with this fixture, the mandrel being placed in the central hole *C*.

* * *

HOW TO FORGE AND HARDEN A COLD CHISEL

BY C. C. SEMPLE*

Some blacksmiths advocate hammering a cold chisel at a black heat to refine and toughen it. After taking the pains to do this, they will replace the tool in the fire and heat it hotter than it was when they began to refine it, after completing the heavy forging. In such cases, the temperature is often still further increased to secure heat enough to draw the temper. When the required temperature has been reached, the tool is taken from the fire and the cutting end is immersed in the bath, part way up the length of the heat. It is then withdrawn and the blade is next polished with a stick covered with emery or with emery cloth. The blacksmith then waits for the temper to run down from the red hot part above the blade, and when the desired temper shows by color, the whole chisel is immersed in the bath. When sufficiently cool, it is given to the man who is to use it.

By this treatment, the blacksmith has undoubtedly undone a part of the mischief and all of the good—if any—that was produced by his cold hammering. In nine cases out of ten, he has heated the vital part of the tool too hot for good refining in order to make the heavy part hot enough to draw the temper. Any steel that will not stand this treatment and make a good chisel is condemned by him.

Now let us see how a blacksmith who keeps the tools in order for a gang of more than 100 men does such work. He takes a piece of steel of the right length for a chisel, heats it to a bright red heat for one-third of its length, and draws the cutting end down on his steam-hammer to about twice its finishing thickness. This being done, he returns the tool to the fire and reheats it to about the same temperature as before. The work is next taken to the anvil, and by means of a hand-hammer and light sledge in the hands of the helper, the chisel is quickly shaped, with the blade still red-hot, or nearly so, when finished. Instead of resorting to cold hammering to refine the steel, the chisel is again returned to the fire, and a second piece that has been getting warmed up on the side of the fire is also moved to the center at this time. The chisel just forged, when heated to a low red heat, is thrust into the annealing box and left to cool. All the subsequent chisels are treated in the same manner, and if any of them are required for immediate use, the ones that were forged first are selected; if not entirely cold, they are plunged into water to make them so.

The hardening process used for chisels cooled by either of the preceding methods is as follows: A piece of iron is laid across the fire and partially buried. The thin edge of the chisel is laid on this iron and the heat allowed to take hold some distance back and run up to the edge. The blade is then dipped and hardened well up, so that in most cases there is not enough heat left to draw the temper. In hardening chisels by this method, the temper is drawn at a light blue. Chisels hardened and tempered in the manner described are put aside for future use, and it is claimed that if they are allowed to remain several days they are better than when used at once.

It may seem that this is quite a rigmarole for forging and hardening so simple a tool as a cold chisel. The question arises, does the end justify the means? The fact that this blacksmith keeps the tools in shape for more than 100 men, and that every one of these men will swear that the tools are the best he ever used in any shop where he has worked, leads to the supposition that there is something in it.

This same method of treatment may be safely applied to all forged tools, so far as omitting the cold hammering and heating of the larger parts to draw the temper is concerned. It is an established fact that many of the high-carbon and alloy steels require reheating to relieve the forging strains and tnat they are improved by being reheated and allowed to cool slowly after forging. It is also an established fact that these steels are ruined if they are hammered at any temperature much below a red heat. The inference is plain that the steel made nowadays does not require the old time blister-steel treatment, and that it will not stand it and yield the best results. The most economical steels to use are now made in such a way that they need no refining on the part of the blacksmith. You will get less hardening cracks by hardening in saturated brine than by hardening in water, but in any case the piece must be kept moving in the hardening fluid. These notes were supplied to the writer by the manufacturer of a well known and extensively used brand of Swedish steel (Fagersta), but the method is equally applicable to all high-grade steels.

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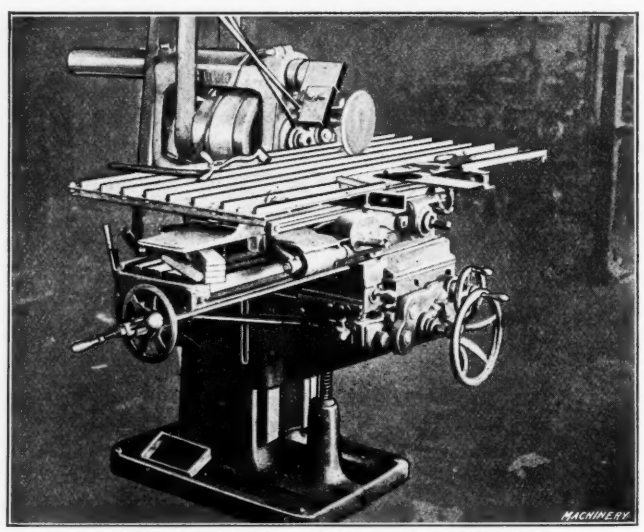
* * *

A COMBINATION OF GRINDER AND MILLING MACHINE

BY S. A. MCDONALD*

The accompanying illustration shows a way of combining two machines to perform an operation on a piece of work which could not be handled otherwise with the average small shop equipment. The work done consisted of a special machine table 5 feet long and 2 feet 2 inches wide, to which were fastened a series of rows of ½ by ¾-inch cold-rolled steel bars. Five of these guide bars were to be parallel within a variation of less than 0.005 inch for their full length; hence, it was considered necessary to grind them.



A Combination of Grinder and Milling Machine

This was a job for a large plain grinder, but, as such a machine was not available, the following method was resorted to:

The platen and grinder bed of a No. 2 Walker grinder were placed on the table of a No. 14A Garvin milling machine, the grinder bed being clamped to the table of the milling machine, and the table to be machined bolted to the grinder platen. By this arrangement the combined travel of the grinder and milling machine tables was sufficient to cover the work. A lathe grinding attachment was fastened to the overhanging arm of the milling machine. This attachment was belted to a pulley on the lineshaft. By shifting the arm in or out, the emery wheel was set to approximately the right position, and the arm clamped. The final adjustment was then made by the transverse feed of the milling machine. The grinding was done with the side of the wheel and a very smooth finish was obtained, well within the limits of accuracy required.

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DYNAMICS OF GAS ENGINE CAMS—2

AN INVESTIGATION INTO THE RELATIVE MERITS OF DIFFERENT TYPES OF CAMS

BY M. TERRY*

In the previous installment of this article an analysis was made of a tangential cam, such as is commonly used in gas engine design for automobile engines. In the present installment, it is proposed to make a similar investigation with relation to a uniformly accelerated and retarded motion cam, in order to definitely determine if the latter possesses advantages over the tangential cam.

In comparing different types of cams, or even cams of the same type, we must make them alike in all respects but the one we wish to investigate. It is evidently impossible to

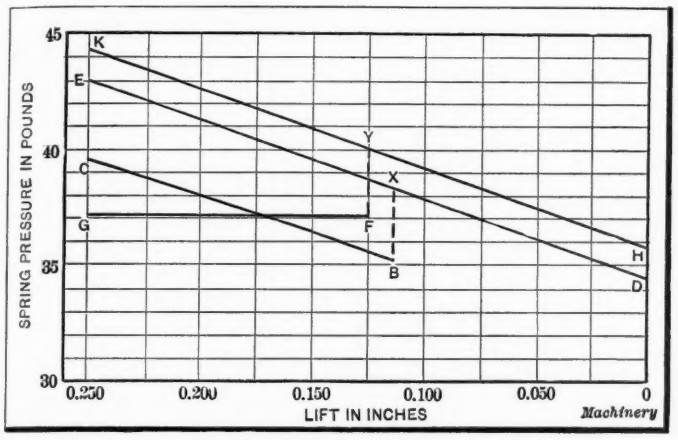

Fig. 14. Spring Pressure Diagram for Tangential and Uniformly Accelerated Motion Cams

draw any conclusions by comparing cams of different lifts and base circles and driven at different speeds, or having followers of different diameters, possessing different clearances and producing different timing of valves.

Since the object of our investigation is to find out which shape of the two cams is more suitable in a dynamic respect, we shall make our uniformly accelerated aand retarded motion cam identical with the tangential cam discussed in the first installment. In other words, our new cam must comply with the following requirements:

Base circle = 1.000 inch in diameter.
Roller circle = 1.000 inch in diameter.
Lift = ¼ inch. Full lift must be attained in the same length of time, *i. e.*, in 53 degrees of the angular motion of the cam.
Weight of reciprocating parts = 1.6 pound.
The same rotary speed, *i. e.*, the camshaft turns through 1 degree in 1/5000 second.
The same timing, which, so far as individual cams are concerned, means that the exhaust and inlet valves should stay open 110 degrees and 100 degrees, respectively.
The same amount of clearance between the valve lifter and the valve stem.

The last item, it will be noted, does not call for the 5 degrees clearance angle assumed with the tangential cam, and the reason for this will be shown presently.

Clearance and Clearance Angle

In the early part of the first installment reasons were given for the necessity of clearance whenever the poppet type of valve is used. The amount of clearance given is, in general, arbitrary, and with different manufacturers it varies from 0.004 to 0.010 inch. With the valve gear arrangement shown in Fig. 15 a backlash of, say 0.006 inch is obtained by inserting a steel gage 0.006 inch thick between *A* and *B*; the timing gears are then adjusted so as to secure the timing originally intended for that motor. When this last object is attained with a reasonable degree of accuracy the screw *B* is locked securely in place, and only a slight pull should be sufficient to remove the gage.

It is clear, then, that the valve lift is equal to the cam lift less the clearance, and that the follower would rise the amount of backlash before the valve proper is started on its upward journey. This loss in valve lift is generally neglected, but its effect on valve timing is universally recognized.

In Fig. 16, *O* is the center of the tangential exhaust cam which turns counter-clockwise. The cam and its follower are shown in the position where the latter starts on its upward motion. As before, assume that the cam is stationary and that the roller moves to the right; its center *C* will describe a straight line CC_2, and in doing so the distance between *O* and *C* will increase. When such a point, C_1, is reached that $OC_1 - OC$ equals the backlash, the valve will begin to open. The angle COC_1 is known as the clearance angle or the angle of backlash.

$$\cos COC_1 = \frac{OC}{OC_1} = \frac{OC}{OC + \text{backlash}}$$

In general, the amount of backlash is assumed first and the angle of clearance is determined afterwards. Since, however, in the case analyzed in the previous installment of this article we have assumed the angle of backlash to be 5 degrees, our first problem is to determine the amount of clearance corresponding to 5 degrees.

$$\cos 5 \text{ deg.} = \frac{1}{1+x}, \text{ or } x = 0.00382 \text{ in.}$$

Our next problem is to determine the clearance angle of the uniformly accelerated and retarded motion cam corresponding to this amount of backlash, *i. e.*, 0.00382 inch.

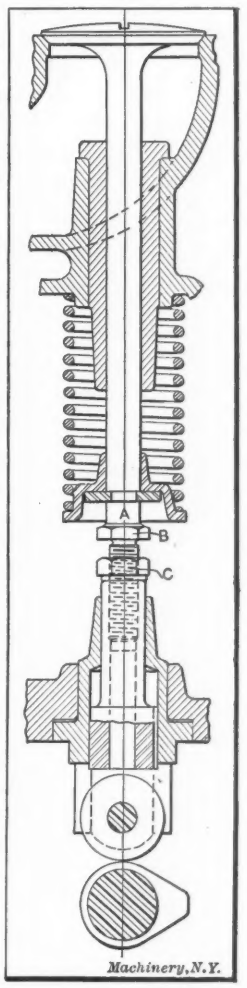

Fig. 15. Valve Mechanism

Uniformly Accelerated and Retarded Motion Cam

Almost every text-book on mechanisms mentions the uniformly accelerated motion type of cam. In our case it would be a cam so shaped as to impart to the roller center a uniformly accelerated motion during the first half of the lift, and a uniformly retarded motion during the second half.

If A = acceleration per second, in feet per second (constant),
t = time in seconds,
v = velocity in feet per second,
S = lift in feet,

Then

$$v = A \times t \qquad (1)$$
$$S = \tfrac{1}{2} A t^2 \qquad (2)$$

These equations can be applied only within the limits of one-half the lift. *A* is unknown for the present, but its value can be readily determined from the last equation. In the present case:

$S = 1/8$ inch, or 1/96 foot,
$t = 26\tfrac{1}{2} \times 1/5000 = 0.0053$ second,

$$A = \frac{2S}{t^2} = 741\ 2/3 \text{ feet per second per second.}$$

To find the clearance angle x corresponding to a backlash of 0.00382 inch:

$$t^2 = \frac{2S}{A} = \frac{2 \times 0.00382 \times 1/12}{741\ 2/3}$$

from which we find $t = 0.000926$ second. But

$$t = x \times \frac{1}{5000},$$

from which $x = 5000 \times t = 5000 \times 0.000926 = 4.63$ degrees, or 4 degrees 38 minutes.

The clearance angle of the uniformly accelerated and retarded motion cam being equal to 4 degrees 38 minutes, the

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total angle of the exhaust cam = 110 deg. + 2 × (4 deg. 38 min.) = 110 deg. + 9 deg. 16 min. = 119 degrees 16 minutes (see Fig. 17), and the total angle of the inlet cam = 109 degrees 16 minutes.

The cam shown in Fig. 17 is what may be termed the equivalent of the tangential cam, Figs. 9 and 10, previous installment.

In order to plot an accurate lift curve (Fig. 18), as well as to draw the contour of our new cam (Fig. 17) we shall make a table of lifts for each degree of the cam.

TABLE IV. ANALYSIS OF UNIFORMLY ACCELERATED MOTION CAM

a	a	L	a	a	L
1	0.000356	0.000178	15	0.000356	0.040050
2	0.000356	0.000712	16	0.000356	0.045568
3	0.000356	0.001602	17	0.000356	0.051442
4	0.000356	0.002848	18	0.000356	0.057672
5	0.000356	0.004450	19	0.000356	0.064258
6	0.000356	0.006408	20	0.000356	0.071200
7	0.000356	0.008722	21	0.000356	0.078498
8	0.000356	0.011392	22	0.000356	0.086152
9	0.000356	0.014418	23	0.000356	0.094162
10	0.000356	0.017800	24	0.000356	0.102528
11	0.000356	0.021538	25	0.000356	0.111250
12	0.000356	0.025632	26	0.000356	0.120328
13	0.000356	0.030082	26.5	0.000356	0.125000
14	0.000356	0.034888	..	.....	.....

Equation (2) may be put in the form:

$$L = \tfrac{1}{2} a a^2$$

where L is the lift of the cam follower in inches, a is the cam angle in degrees, and a the acceleration per degree, in inches per degree; this acceleration is, of course, constant and can be readily determined:

$$a = \frac{2L}{a^2} = \frac{2 \times 0.125}{(26.5)^2} = 0.000356 \text{ inch.}$$

(Since full lift is attained in 53 degrees, a lift of 0.125 inch corresponds to an angular motion of 26½ degrees.)

Knowing now the value of a, and by assigning various values to a in the equation just given, we can determine the lift or position of the roller center for every degree of the cam. This is done and the results are compiled as shown in Table IV. With the help of this table we can now plot a complete lift curve, since the latter is symmetrical both with respect to XX and YY, Fig. 18.

Again, with O as the center of our cam (Fig. 17) strike two arcs AA of 1 inch radius and CC of 1¼ inch radius, and from intersections of these arcs with the radial lines of the cam lay off proper lengths as indicated in the third column, Table IV. A line through the points thus obtained represents the path of the roller center; if from these points as centers we strike a number of arcs the radii of which are equal to the radius of the roller, the curve drawn tangent to these arcs will give us the contour of the cam.

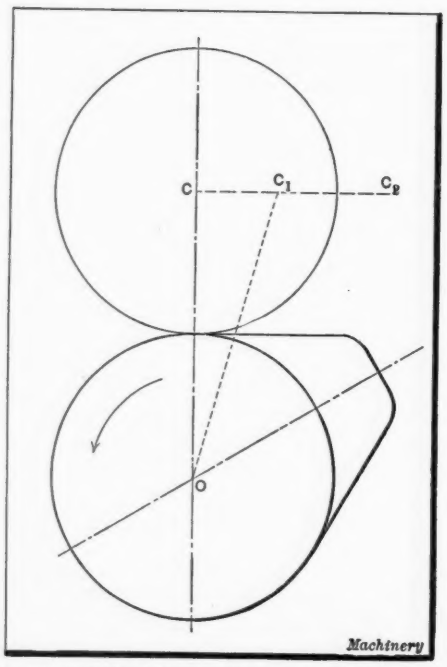


Fig. 16. Relation between Clearance and Clearance Angle

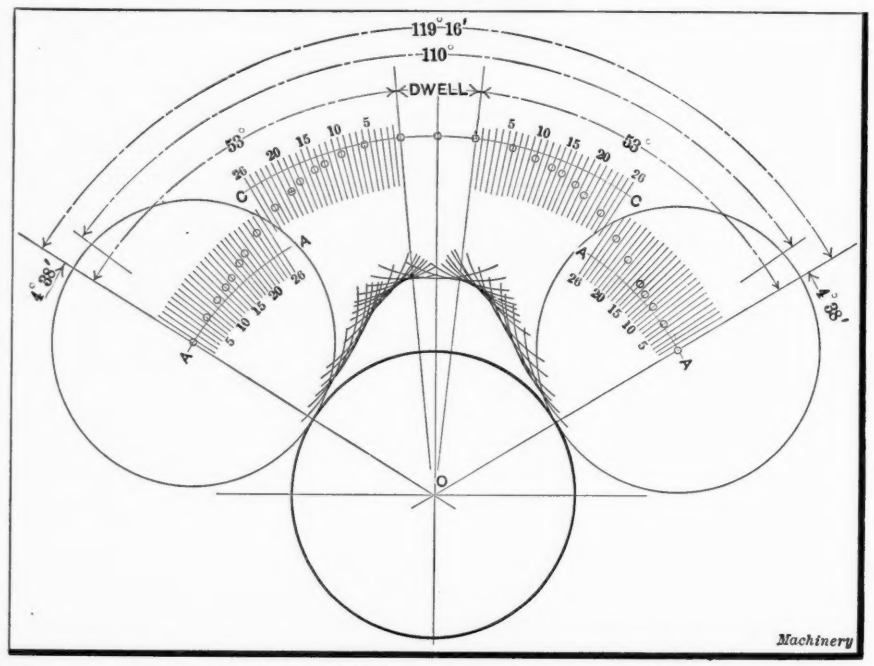


Fig. 17. Lay-out of a Uniformly Accelerated and Retarded Motion Cam

The Valve Spring

In the previous installment we have fully discussed the functions of the cam and of the valve spring, and the conclusions there arrived at hold good for the uniformly accelerated and retarded motion cam. It remains now to select a suitable valve spring. If

T = spring pressure in pounds,

A = acceleration per second in feet per second required by the cam,

m = total mass of the reciprocating parts of the valve gear plus one-half the mass of the spring proper, we have:

$$T = m \times A = \frac{A \times 1.6}{32} = \frac{742 \times 1.6}{32} = 37.1 \text{ pounds.}$$

Since A is constant, 37.1 pounds of pressure is all that is required of the spring at any point from one-half to full lift of the cam. In other words, the ideal spring for a uniform motion cam is the one whose stress-strain curve is a horizontal line. This, of course, is an impossibility, for within its elastic limit any spring will exert pressure directly proportional to its distortion.

In Fig. 14 (reproduced from the previous installment) the line FG represents the spring pressure required by the uniformly accelerated and retarded motion cam. If we wish to use the same spring that we have designed for the tangential cam, and give it the same excess of pressure at F as it has anywhere between the lines BC and DE, we shall obtain HK for our actual spring pressure line. This would give us a spring, the initial and final pressures of which are 35.8 pounds and 44.4 pounds, respectively. In other words, a greater spring pressure is required for the uniformly accelerated and retarded cam.

Our conclusions in regard to the relative stiffness of springs required for the two cams are substantiated by an actual test of two engines identical in every respect but for the shape of their timing cams. The two engines were originally equipped with identical valve springs. The follower of the uniformly accelerated motion cam developed a tendency to "jump" the cam at from about 2100 to 2200 R. P. M. of the engine; the follower of the tangential cam showed signs of the same tendency when the engine speed exceeded 2400 R. P. M. The "jumping speed" of the first follower was raised to about 2500 R. P. M. by equipping its motor with additional valve springs.

The two motors were built for racing purposes, and if the writer remembers correctly, the valve lift was 7/16 inch (unusually high for automobile engines); the weight of reciprocating parts of the valve gear was 2.7 pounds, and the spring pressures were 175 pounds for the tangential and about 200 pounds for the uniformly accelerated motion cam. The experiment referred to took place over two years ago, and its results were contrary to the expectations of all concerned, for the prevailing opinion among designers is that of the two cams it is the tangential one that requires the stronger spring. To quote Mr. P. M. Heldt (*Horseless Age*, July 5, 1911, pages 4 and 5): "* * * this computation is based on supposition that acceleration and deceleration of the valve are uniform. With a tangential cam this is not the case, and the spring should then be made slightly stronger."

The author takes exception to this opinion. A glance at Fig. 14 will suffice to convince anyone who is even slightly familiar with mechanics. Assume a multiple cylinder engine equipped with cams of both types; the valve springs are all alike, their pressure line being represented by *DE*. As the speed of the engine rises above the assumed maximum, the lines *BC* and *FG* would rise parallel to themselves; *DE* would, of course, remain stationary, for the spring pressure is independent of the engine speed. It is clear, then, that *FG* would be the first line to cross *DE*, or to put it in other words, the uniformly accelerated motion cam would be the first one to exceed the capacity of the spring.

It would not be out of place here to mention the fact that if one is very anxious to prove the contention that a tangential cam requires more spring pressure than one with a uniformly accelerated motion outline, he can easily do so by "juggling"

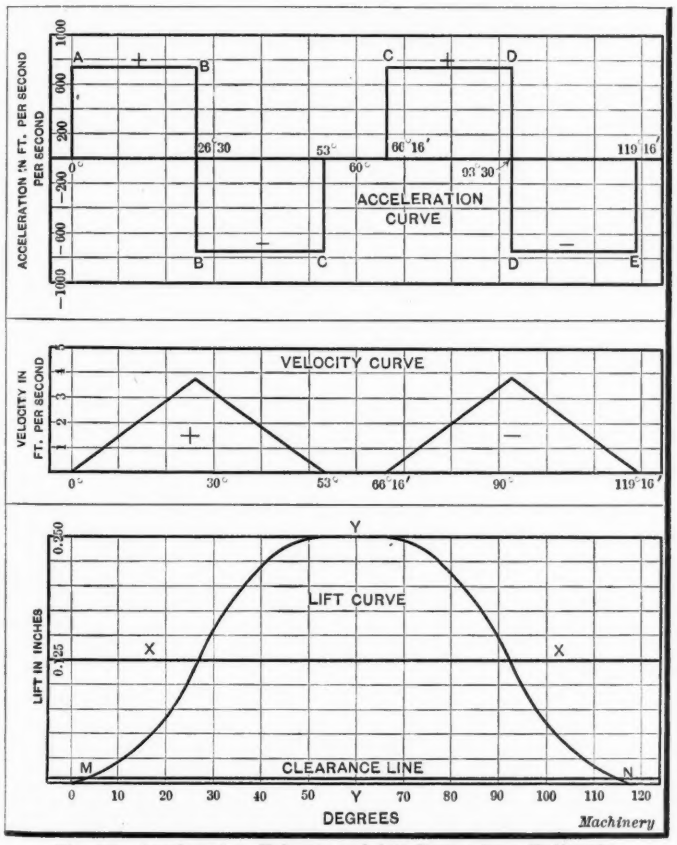


Fig. 18. Acceleration, Velocity and Lift Curves for a Uniformly Accelerated and Retarded Motion Cam

with the former. For instance, he can take the cam described in the first installment and give it a fillet of 1/16 inch radius instead of ⅛ inch. This will put a heavier duty on the spring, requiring it to perform the work of retardation and of acceleration in less time; but in this respect our comparison of the two types of cams has been absolutely fair, for not only was the total time required to lift the valve to its full height the same in both cases, but in each case the time was equally divided between acceleration and retardation, and that is as far as one can go in making the two cams alike. The only difference between them lies in the nature of their accelerations: it is constant in one and variable in the other; and, as has already been proved, in the case of the tangential cam it varies in such a manner as to favor the spring.

Origin of Noise

In a lecture delivered before the automobile class of the West Side Y. M. C. A., New York, Mr. C. E. Reddig, engineer of the United States Motor Co., speaking on the Silent-Knight motor, said, in part:

"The Knight engine is not different from standard engines, except in its valves; the cycles are performed in the usual manner, the gas is drawn from the carbureter, is compressed,

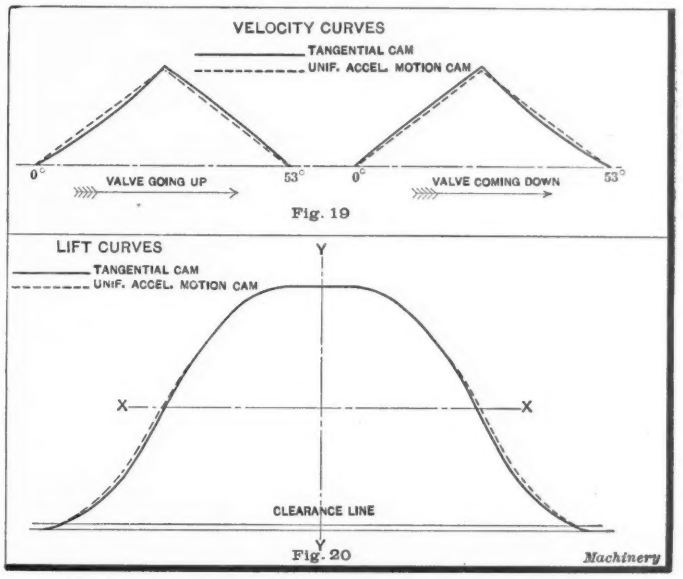


Fig. 19. Comparison of Velocity Curves. Fig. 20. Comparison of Lift Curves

combustion takes place, and it exhausts, in the same manner as in any of the four-stroke cycle engines.

"The changes which in the Knight engine constitute the great improvement over ordinary types of engines are the silent, tremorless, sliding sleeves working away perfectly without care or attention. They make no noise, for they strike nothing. They cause no vibration."

Indeed, they make no noise, for they strike nothing. Not so with the poppet valve. In what follows we shall limit our discussion to the type of mechanism shown in Fig. 15. The complete lift curves, Figs. 12 and 18, represent the motion of the follower and of all the parts rigidly connected to it. The motion of the valve proper, while following along the same curve, does not commence until after the cam follower rises the amount of the backlash. In other words, the valve motion begins at *M*, the point of intersection of the lift curve with the clearance line; likewise it ceases at *N*.

If at *M* and *N* we erect ordinates until they intersect the velocity curve, the cause of noise will become apparent: 1. The cam follower possesses a definite velocity at the instant it comes in contact with the valve stem. 2. The valve possesses the same velocity when its head comes in contact with the valve seat. Whenever two bodies possessing different velocities come in contact, impact takes place; and in the case of poppet valve engines, there are two impacts per cycle for each valve in the engine.

The impact due to the valve striking its seat can be most readily analyzed. Owing to the rigidity of construction of both the valve head and the cylinder casting, practically no deformation of either can take place after the impact, and, consequently the velocity of the valve must vanish almost instantly. At the instant the valve strikes its seat, the former, owing to its velocity, possesses a definite amount of kinetic energy, the value of which is $\frac{1}{2}\ mV^2$, where m is the combined mass of the valve, and of all the parts attached to it, plus one-half the mass of the valve spring, and V is the velocity of the valve at the instant it strikes the seat. Since, after the impact, V vanishes almost instantly, the kinetic energy of the valve must also completely disappear. However, energy cannot be created nor destroyed, and the kinetic energy of the valve merely undergoes a transformation and reappears in other forms of energy, namely: heat and sound.

In just what proportion the kinetic energy resolves itself

into the above two forms is, of course, impossible to tell. Simple observation seems to indicate that the pounding noise increases very rapidly with the speed of the engine, and we are justified in making the assumption that, at all ordinary engine speeds, noise constitutes a constant percentage of the kinetic energy of the valve at the moment of impact. We can write then:

$$\text{Noise} = c \times \tfrac{1}{2}\, m\, V^2 = K\, V^2$$

where K is a constant.

This assumption is very useful for the purpose of comparing the pounding action of valves due to different cams.

Tangential vs. Uniformly Accelerated Motion Cams

Sub-figures $(_1)$ refer to uniformly accelerated motion cam, and sub-figures $(_2)$ to the tangential cam.

Let S_1 = backlash in feet,
A_1 = acceleration per second, in feet per second,
V_1 = velocity of the valve in feet per second at the moment of impact,
β_1 = angle of backlash = 4 deg. 38 min., or 4.63 degrees,
t_1 = time in seconds required for the cam to turn through the angle of backlash = $\beta_1 \times 1/5000$.
S_2 = backlash in feet,
A_2 = average acceleration per second, in feet per second during the angle of backlash,
V_2 = velocity of the valve in feet per second at the moment of impact,
β_2 = angle of backlash = 5 degrees (see previous installment),
t_2 = time in seconds required for the cam to turn through the angle of backlash = $\beta_2 \times 1/5000$.

Then

$$V_1 = A_1\, t_1 \qquad (3)$$
$$V_2 = A_2\, t_2 \qquad (4)$$
$$S_1 = \tfrac{1}{2}\, A_1\, t_1^2 \qquad (5)$$
$$S_2 = \tfrac{1}{2}\, A_2\, t_2^2 \qquad (6)$$

Substituting (3) and (4) in (5) and (6), respectively, we obtain:

$$S_1 = \tfrac{1}{2}\, V_1\, t_1 \qquad (7)$$
$$S_2 = \tfrac{1}{2}\, V_2\, t_2 \qquad (8)$$

But $S_1 = S_2$, since the amount of backlash allowed was the same in both cases. Hence $\tfrac{1}{2}\, V_1\, t_1 = \tfrac{1}{2}\, V_2\, t_2$ (9)

and
$$\frac{V_1}{V_2} = \frac{t_2}{t_1} \qquad (10)$$

Now since $t_1 = \beta_1 \times 1/5000$ and $t_2 = \beta_2 \times 1/5000$,

$$\frac{t_2}{t_1} = \frac{\beta_2}{\beta_1} \qquad (11)$$

Substituting (11) in (10):

$$\frac{V_1}{V_2} = \frac{\beta_2}{\beta_1} = \frac{5}{4.63} \qquad (12)$$

Now, then, everything else being equal, we can write:

$$\frac{\text{Noise due to the uniformly accelerated motion cam}}{\text{Noise due to the tangential cam}} = \frac{V_1^2}{V_2^2} = \frac{\beta_2^2}{\beta_1^2} = \frac{5^2}{4.63^2} = 1.16,$$

or 16 per cent greater.

The fact that in the early stages of opening and the late stages of closing, the valve velocity due to the uniformly accelerated motion cam is greater than that due to the tangential cam can be shown graphically by superimposing the velocity curves of the two cams. (See Fig. 19.)

Lift Curves Compared

Our study of the two cams would remain incomplete if we failed to compare their lift curves. As a matter of fact, these are the only curves that the majority of designers ever take pains to construct and to compare. The object of their comparison, however, has nothing to do with the dynamics of the cams themselves.

In Fig. 21 is shown what is known as a flat-seated valve. The effective area for the passage of gases is that of a cylindrical surface whose diameter is D and whose height is Y. This area is equal to πDY, where π and D are constants, and Y at any instant is the actual rise of the valve. When a cone-seated valve is used, the relation between the effective area-opening and the valve lift is somewhat more complicated.

It is the aim of every designer to provide as large gas passages as possible in order to increase the volumetric efficiency, and—along with it—the output of his engine. At any instant, then, the lift regulates the amount of charge admitted, and, thus, the former can graphically represent the latter. The total charge taken in during the suction stroke of the engine, and consequently, the output of the latter can be represented by the lift-integral, *i. e.*, by the area bounded by the lift curve and the clearance line.

It is clear, then, that the output of the two identical engines equipped with different cams would be approximately proportional to their lift-integrals, and it is for the sake of

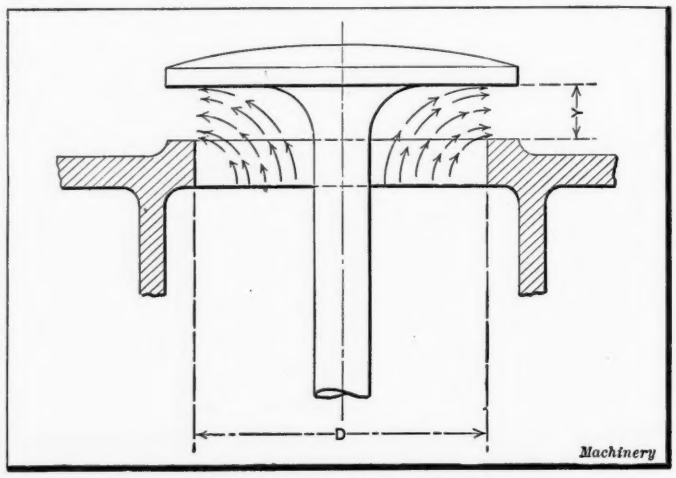


Fig. 21. Relation between Lift and Discharge Area

comparison that we have superimposed the lift curves of our two cams, as shown in Fig. 20. The advantage is in favor of the uniformly accelerated motion cam, but the amount of this advantage is very slight, as anyone can see at a glance.

To sum up our results:

1. A tangential cam requires less spring pressure than a uniformly accelerated and retarded motion cam.
2. It produces less noise.
3. It can be manufactured more cheaply and accurately.
4. The indicated horsepower of the engine would, in all probability, be the same, no matter which type of cam were employed.

* * *

OIL-MIXED PORTLAND CEMENT CONCRETE

A serious drawback to the general use of concrete for tanks, cisterns, house walls, cellars, etc., is its permeability to moisture. A concrete cistern, unless specially treated, is likely to be leaky, and even if leakage is not serious, it is usually objectionable on account of the dampness resulting from it. Concrete block houses are often damp and unhealthful. Several formulas for making concrete waterproof have been successfully used but some of them are too expensive for general application. One of the simplest, cheapest and most effective yet found is that developed by the U. S. Geological Survey in the office of public roads by Mr. L. W. Page. Mr. Page found that a heavy residual mineral oil of 0.93 specific gravity, mixed with Portland cement, makes it waterproof and does not weaken when the concrete consists of, say, cement, one part, sand, three parts, and oil not more than ten per cent by weight of the cement. Concrete mixed with oil requires about fifty per cent longer time to set hard, and the compressive strength is slightly decreased, but not seriously. The bond or grip of oil concrete on steel is much decreased when plain bars are used, but formed bars, wire mesh or expanded metal act as effectively in it as in ordinary concrete.

* * *

It has hitherto been believed that pitchblende, the mineral containing the largest amount of radium of any mineral known, was principally to be found in Austria. It is now stated, however, that this mineral is found in even greater quantities in one of the northern provinces of Sweden, and that it is only a question of time when these deposits will be worked for obtaining the radium contained in them.

MODERN METHODS OF A PRESS WORKING PLANT

DESCRIBING WORK DONE BY THE WORCESTER PRESSED STEEL CO.

BY CHESTER L. LUCAS*

Nestling under a hillside at Greendale, one of the pretty suburbs of Worcester, Mass., are the works of the Worcester Pressed Steel Co., an "aviator's view" of part of which is presented in Fig. 1. The buildings of the plant embrace the main press working factory; the foundry for making special tool castings for dies, die beds, etc.; a new building for pickling, with ventilated roof 45 feet high; the rolling mill for cold-rolling strip steel; the acetylene gas generating house; the annealing and casehardening building; the storage and shipping building; the office building and the power house. The business was established in 1883 under the name of the

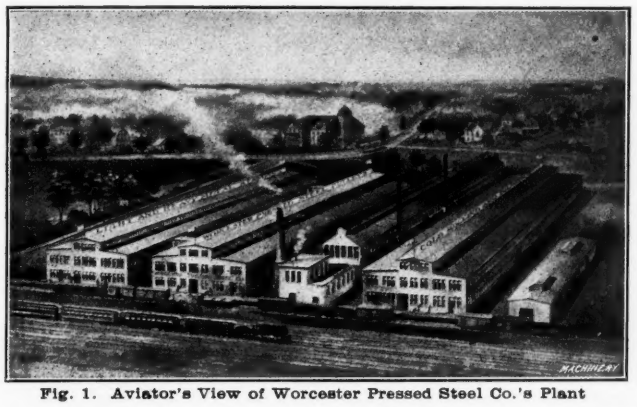


Fig. 1. Aviator's View of Worcester Pressed Steel Co.'s Plant

Worcester Ferrule & Mfg. Co., at which time it occupied 7000 square feet of floor space and employed 20 hands. At the present time the plant covers 70,000 square feet of floor space and gives employment to 250 men.

This manufactory specializes in cold drawing, pressing, forming and stamping shapes to order from steel, brass, aluminum and other sheet metals.

Rolling the Metal

On account of the accuracy and various thicknesses of steel required for pressed and seamless drawn metal products, as well as the necessity for having sheet metal with highly finished surfaces, this company maintains a pickling and rolling department of its own, for cold-rolling the steel to its finished gage. A section of this department is shown in Fig. 2. On the two machines shown, the steel rolls themselves are 12 inches in diameter. During the rolling operation, the rolls are kept flooded with oil. To furnish adequate facilities for this work, a new building 70 feet by 110 feet has just been completed and equipped with most modern vats, cranes and appliances. Work has also been started on another new cold-rolling mill, 150 feet by 100 feet in size and of steel and

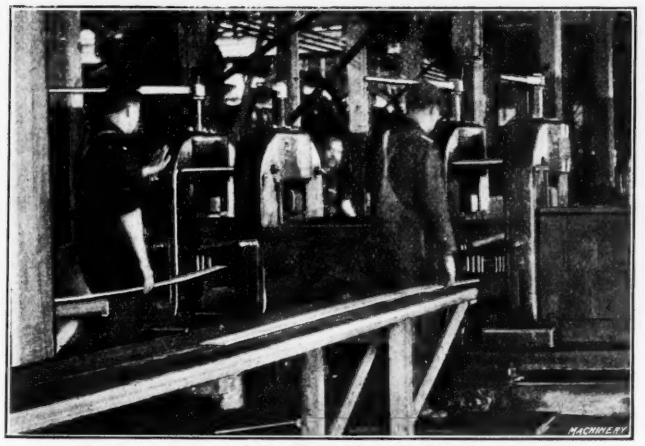


Fig. 2. A Corner of the Sheet Metal Rolling Department

glass construction. A fireproof addition to the main press shop, 90 feet by 100 feet in size, is now being erected.

Making Radiator Fans

One of the interesting jobs of press work done in these works is the making of a one-piece steel fan for an automobile radiator. These fans are 14 and 16 inches in diameter, made of cold-rolled sheet steel 0.035 inch thick, and reinforced at the edge by an enclosed wire ring which stiffens the entire fan. The different stages in making the fan may be seen by

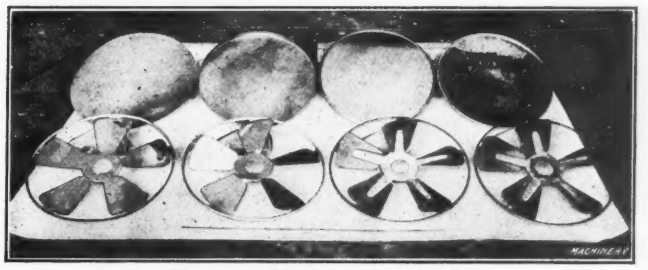


Fig. 3. Evolution of a Radiator Fan

referring to Fig. 3. Commencing with the blank at the left-hand upper corner, these pieces represent the work done: blanking; flanging edge; closing in preparatory to wiring; closing the wire in position; piercing between the blades; shaping the blades; electrically welding the spider and hub; and piercing the rivet holes in the hub.

The blanking, flanging and closing-in operations are ordinary jobs of press working. The welding operation which

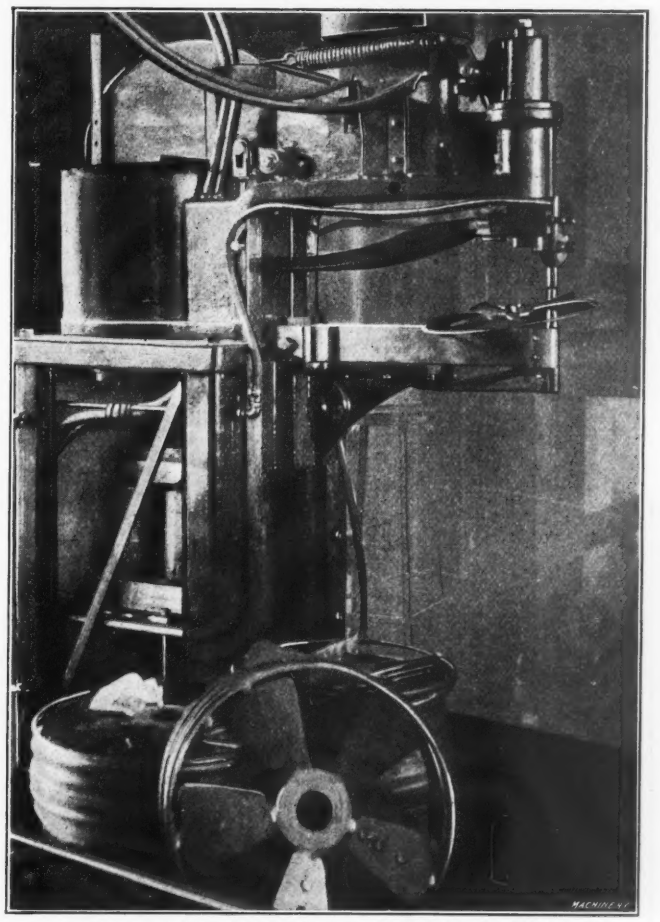


Fig. 4. Welding Fan Blades on a National Spot Welder

connects the spider with the blades of the fan is performed upon a National electric welding machine, known as a spot welder. This operation is shown in Fig. 4. A helper clamps a spider upon the fan with a simple fixture, which centers the hole in the spider with the opening in the fan and holds both parts securely in place. This being done, the welding machine operator spot-welds an arm of the spider to a corresponding blade on the fan, hands it back to the helper, who has, in the meantime, prepared another fan and spider for welding. The helper now removes the fixture from the fan and the welder completes the work on the other blades, while another fan is being placed in the fixture. There are three welds to each blade and fifteen welds to a fan. A welder and a helper will

* Associate Editor of MACHINERY.

turn out about 400 fans per day of ten hours, which makes a total of about 6000 welds per day. There are four of these machines in this department.

Cold Forging

A somewhat unusual branch of press work was developed and is followed to a considerable extent in this shop, *viz:* cold forging. Cold forging is the name commonly applied to the process of producing sheet metal shapes or pieces having

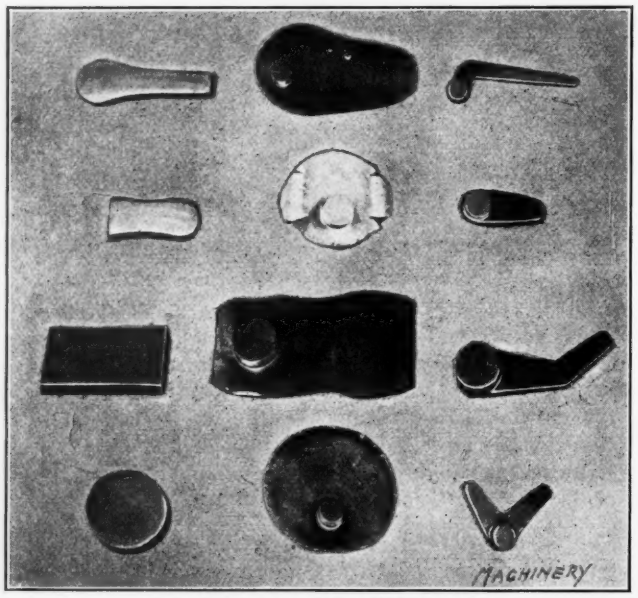


Fig. 5. Steps in making Cold-forgings

raised bosses or projections upon their surfaces. Some typical examples of this class of work, as well as the steps followed in making them, are shown in Fig. 5. Such work requires

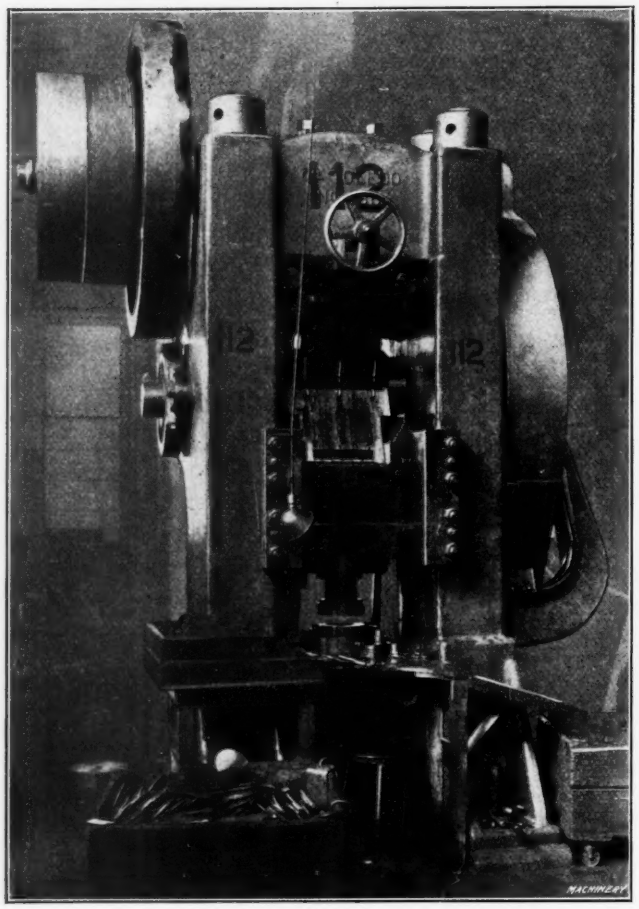


Fig. 6. Heavy Knuckle-joint Press used for Cold-forging

powerful presses, the samples shown being made in a heavy, 1000 ton capacity knuckle-joint, Toledo press, which is shown in Fig. 6. Needless to say, such work requires dies that will stand this heavy pressure, and Vulcan steel is one of the steels which has proved very satisfactory for these dies. In the making of pieces of this nature, blanks are used which are oftentimes waste punchings from the production of other pieces. These pieces are struck between the dies, which, except for the depressions for forming the bosses or panels, are flat. Such being the case, the result of this cold forging operation leaves the work in the condition shown by the

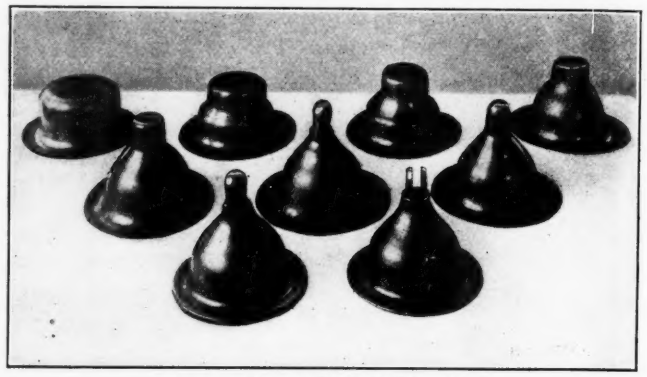


Fig. 7. Making a Difficult Stamping

central pieces of each of the groups in Fig. 5. In each case, the blanks are shown to the left. All that now remains for the completion of the pieces is to run them through blanking operations to trim off the surplus metal. While there is nothing especially difficult about doing this class of work after the tools and methods are designed, it requires

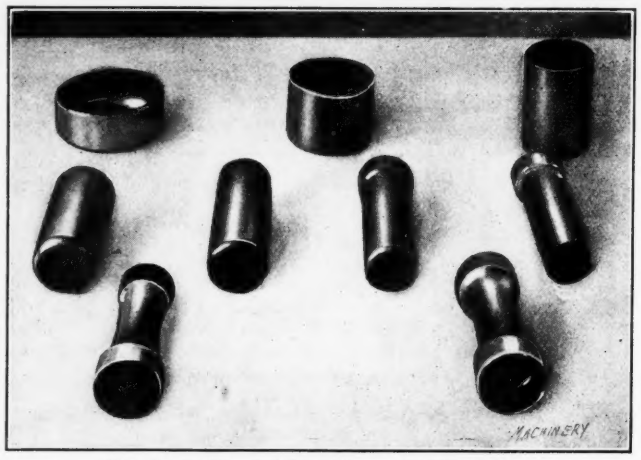


Fig. 8. An Unusual Stamping and its Evolution

presses which are extremely powerful, and above all, dies which will withstand the severe work they must do.

Successive Steps in Forming Typical Stampings

Three sets of stampings showing the steps taken in making the respective pieces are shown in Figs. 7, 8 and 9. In Fig. 7, the piece shown is very difficult to produce, mainly on account of the small diameter of the small end. In producing this piece, the first step consists of cupping the blank, as shown at the extreme upper left-hand corner. From this blank, the stock is gradually worked toward the point to get enough metal into position to form the narrow thimble-shaped

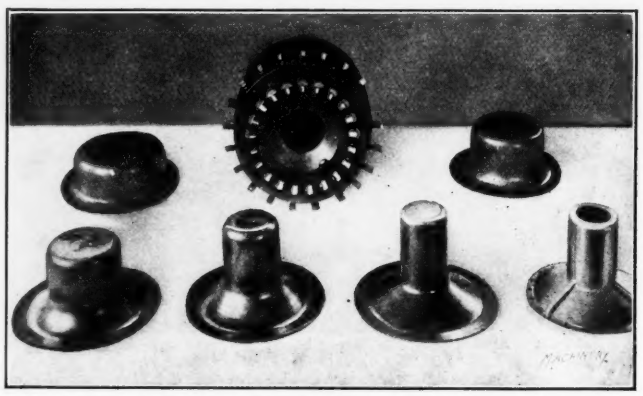


Fig. 9. Steps in Drawing a Flanged Cup and the Last Operation Punch

end, without enough strain being exerted upon the metal to tear it. The pierced end is, of course, the result of the final operation. The metal is kept a uniform thickness throughout.

In Fig. 8, an unusual piece of work is shown in the making

of a special steel ferrule. The difficulty in producing this ferrule lies in the fact that it must be opened out from the small end after being drawn. It takes nine operations to complete this piece, the first operation consisting in drawing the shell in the usual way, leaving a shoulder at the mouth, and the final operations consists of punching out the bottom, expanding the small end and shaping the finished piece.

In Fig. 9, six steps in making the special stamping at the right-hand lower corner are shown, together with the piercing punch used in the final operation. Up to this final operation, the work consists of plain drawing, but the last operation embraces the cutting of the central hole, the formation of the ribs on the beveled section, and the piercing of the small cuts around the edge. It will be noticed that these cuts are not round holes, but are made by a combined shearing and forming operation effected by the special punch shown in the center of the illustration. The individual punches on this tool are held in position by set-screws so that they are easily renewable if broken.

Perforating Tools

Except by those directly connected with the manufacture of telephone mouth-pieces, it is not generally known that the best type of these pieces is made with a steel core beneath a hard rubber covering. It is, of course, apparent that the strength of such a mouth-piece exceeds the solid rubber article, and, moreover, more durable threads are secured when cut in the steel core than is the case when the threads are cut directly in the rubber. For the purpose of making the rubber adhere firmly to the steel core, it is necessary that perforations be made in the metal, through which the rubber can run. Two sets of tools for this operation are shown in Figs. 10 and 11. Fig. 10 shows the simpler set in which the die is mounted within the arbor, which is shown just behind the operator's left hand. This arbor is, in turn, supported by a base which is clamped to the press bed. The punch is shown directly over the arbor which, of course, holds the die. For indexing, a spring finger, the rear end of which is shown in contact with the operator's finger, is supported by a suitable bracket from the base of the fixture. Pressure upon the end of this finger causes the gaging end to extend, and the slot previously cut in the core is turned against the end of this finger while the next slot is being punched. This operation is repeated until all six of the slots have been perforated, when the finger is released and springs back out of the way. After the completed piece has been taken from the arbor, the six pieces of scrap drop through the arbor.

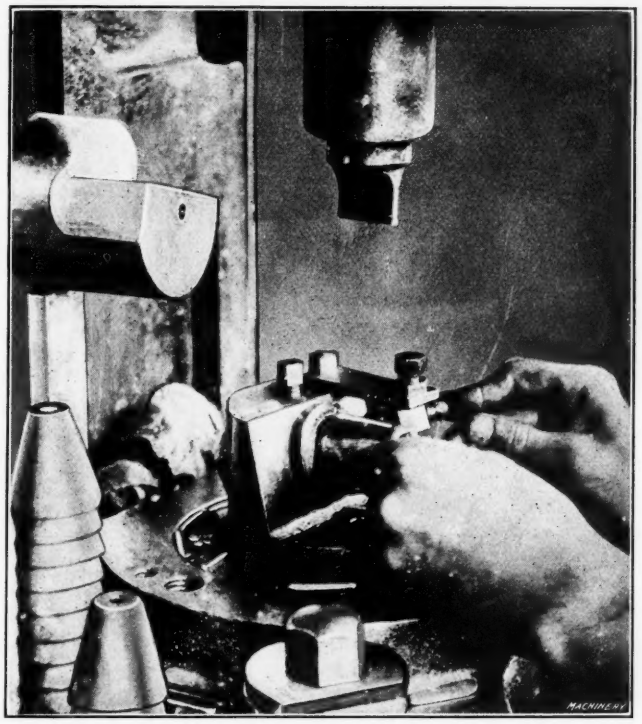


Fig. 10. A Simple Set of Perforating Tools

A second set of perforating tools is shown in Fig. 11. These tools are a little more complicated in design, but they are also more efficient and more interesting. They consist essentially of the bedplate upon which the base block of the fixture is mounted, supporting the work on the arbor, which may be seen at the center of the illustration. The punch is fitted with a spring stripper. The die, of course, is mounted in the arbor. Rotation of the work upon the arbor is secured by means of the automatic indexing mechanism, which is operated through a bracket that extends downward from the ram of the press. This bracket is fitted with adjustable button head "pushers" which reciprocate the end of the lever, one end of which appears between the pushers. This lever communicates with the indexing plate by means of a pin at its opposite end. A handwheel operates a friction disk which acts against the end of the work. When the lever is depressed, the index plate turns the work by means of a ratchet, just ⅛ of a revolution; therefore, after the press has operated continuously for eight revolutions, a new piece is put on the arbor. The latch at the extreme lower right is used to facilitate the removal of the work.

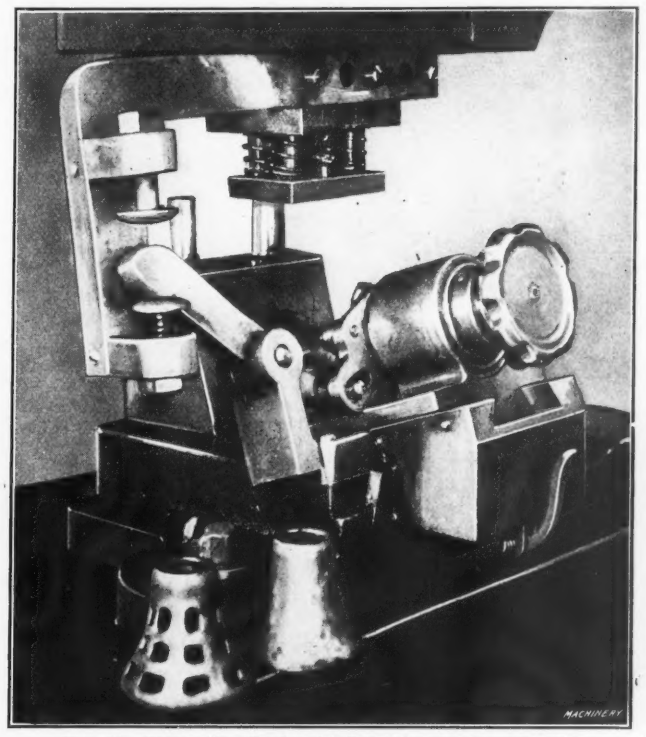


Fig. 11. Perforating Tools with Provision for automatically rotating the Work

Fig. 12. Flexible Bins and Steel Buckets for Handling Stampings in Quantities

An important part of the work done by this concern is making high-grade rear axle housings, brake drums, hub flanges, hub caps, ball bearing cups and retainers, and other stamped parts for automobiles, motorcycles, bicycles, cream separators, textile and electrical machinery, and for many other purposes.

Production Methods

For handling steel stampings in large quantities many unusual methods are employed. In Fig. 12 may be seen a method

of bin construction which is used for handling heavy stampings in large lots. These bins consist of sections which may be fastened together, forming a semi-flexible arrangement that may be moved to any position on the floor and expanded or contracted at will, as there is no bottom. A method of transporting work about the factory, is by means of sheet steel buckets handled by an electric traveling crane. Punchings and stampings except those which are light and easily bent, are thus treated like so much building material, being shoveled into the bucket and dumped from it in the same manner. Small cans like that shown at the right, are common to all shops for holding small quantities of work.

Power is derived from a hydro-electric plant, situated on the Connecticut River, sixty miles away. This power is carried to the factory at a tension of 23,000 volts, at about half the cost of steam power if produced by coal at the plant. All the presses are driven by individual electric motors.

Credit is due Mr. F. C. Cutler, sales manager of the above company, for cooperation with the writer in preparing this article.

* * *

STOVE-BOLT TAPS

BY A

In the March, 1909, number of MACHINERY, an article accompanied with tables was published giving data for the making of stove-bolt taps. As is well known, there is no standard for this class of taps that has been accepted by all the different makers, and the diameters of taps made by different manufacturers vary to a great extent. The dimensions given in the upper part of the table below represent the practice of two of the more prominent tap manufacturers, the dimensions of whose stove-bolt taps agree with slight (and practically unimportant) differences. The dimensions for the pitch diameters have been obtained by measuring the taps with the ordinary type of screw thread micrometers for the standard number of threads per inch within the range of each micrometer. As the thread, however, is not a regular U. S. standard thread, but is provided with a wider flat at the bottom of the thread than that corresponding to the number of threads per inch in the taps, care had to be taken when measuring these angle diameters so that the spindle would not bear upon the flat in the bottom of the thread; in other words, the point of the spindle at *A*, in the accompanying illustration, had to be flattened sufficiently so as to clear the bottom of the threads.

It will be seen that some of the dimensions differ from those given in the March, 1909, number. It would, of course, be desirable to the trade if all the tap manufacturers could agree upon one standard, and it is believed that the table given herewith represents the practice to which probably the largest proportion of this class of taps conform. The thread has an angle of 60 degrees, with an arbitrary flat on the top, and a flat at the bottom corresponding to that of the standard U. S. thread for pitches coarser than the actual number of threads per inch in the tap. Hence the taps can be cut with regular U. S. standard thread tools selected for a coarser pitch than that of the thread to be cut. For example, when cutting the thread in a 3/16 inch stove-bolt tap, the lathe is geared to cut 24 threads per inch, but a threading tool for 20 U. S. standard threads per inch is used. It is of considerable advantage to settle upon a width at the bottom of the thread that corresponds to certain U. S. standard threads, because the expense and trouble connected with making special thread tools for these taps is thus avoided. As was mentioned in the previous article referred to, stove-bolt taps are made considerably larger in diameter than is the diameter of the screw, so that the nuts have a loose fit—a fit, in fact, that would not be tolerated for regular U. S. standard bolts and nuts. All taps of this kind have four flutes.

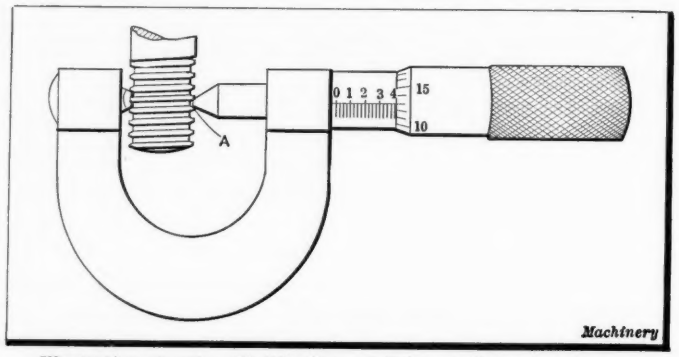
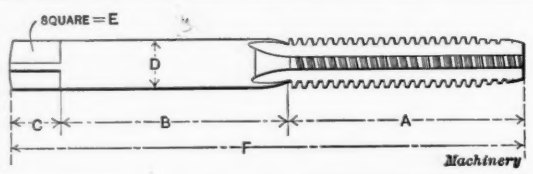


Illustration showing Modification of Point of Measuring Screw of Thread Micrometer for measuring Threads with Very Wide Flat at Bottom

TABLE OF STOVE-BOLT TAPS



Nominal Size	Actual Outside Diameter	Pitch Diameter	Root Diameter	Flat in Bottom of Thread Corresp'ding to	Flat on Top of Thread, Inches	Number of Threads Per Inch
5/32	0.166	0.1500	0.134	20 U. S.	0.0110	28
3/16	0.197	0.1745	0.152	20 U. S.	0.0094	24
7/32	0.223	0.1965	0.170	18 U. S.	0.0079	22
1/4	0.257	0.2285	0.200	11 U. S.	0.0112	18
5/16	0.317	0.2855	0.254	10 U. S.	0.0067	18
3/8	0.354	0.3165	0.279	10 U. S.	0.0067	16

Nominal Size	A	B	C	D	E	F
5/32	7/8	1 5/32	7/32	0.166	1/8	2 1/4
3/16	15/16	1 1/16	1/4	0.197	9/64	2 3/8
7/32	15/16	1 1/4	1/4	0.223	11/64	2 7/16
1/4	1	1 7/32	9/32	0.257	3/16	2 1/2
5/16	1 1/8	1 5/16	5/16	0.317	15/64	2 3/4
3/8	1 1/4	1 5/16	3/8	0.354	9/32	2 15/16

* * *

THERMO-ELECTRIC METHOD FOR TESTING THE STRENGTH OF MATERIALS

An interesting development in the testing of the strength of materials is that known as the thermo-electric method. It has been found that a bar of a given material, upon being subjected to a tensile stress, will absorb heat as long as the stress does not exceed the elastic limit of the material, but that beyond this limit heat will be generated by the friction of the particles sliding over each other. The observations are made by thermo-electric couples, the terminals of which are connected to a sensitive galvanometer. The elastic limit of the material is recognized by the reversal in the temperature curves, presuming, of course, that the temperature indication does not lag behind the stress to which the material is subjected. The extended experiments undertaken by Messrs. T. R. Lawson and J. A. Capp of Schenectady, N. Y., as recorded in a paper before the International Association for Testing Materials, at its congress, September, 1912, indicate, however, that the break in the thermo curve invariably occurs at a higher stress than the elastic limit, as shown by the extensometer.

* * *

FOURTH DIMENSION SPACE ANALYSIS

In a paper on the "fourth dimension" published in the *Polytechnic Engineer* for 1912, William J. Berry mentions a practical use for the mathematical analysis developed to prove the existence of four-dimensional space as follows: "The problem of motion in three-space is stated in terms of four variables—three for space and one for time. Now it is a well-known fact that the analogous problem in two-space may frequently be simplified by regarding it as a geometrical problem in three-space. The suggestion of a geometry of four dimensions to perform a like service for the problem of motion in three is inevitable. This is what makes four-dimension space analysis important, and is, in a large measure, the justification for its study."

THE MECHANICAL TESTING OF FILES*

THE DEMAND FOR STANDARD MECHANICAL TESTS AND TEST METHODS

BY GEORGE W. BURLEY†

The association of standard test specifications with the purchase of engineering materials and tools is a distinctly modern condition, though in certain outstanding cases, engineering materials have been purchased subject to their satisfactorily passing prescribed tests (more or less standard) for a considerable time. At present, however, it is an almost universal practice to demand standard tests on materials and tools where variations can exist in composition, design, construction, or manufacture. Practically nothing is left to chance, and any material or tool which does not excel, or at least equal the test standard, is rejected; if such material or tool represents a sample of any given quantity, the entire quantity is likewise condemned and rejected. The matter of a standard test is a most important one when viewed in connection with large contracts, as the acceptance of large quantities of materials or tools, which are not of the best quality obtainable at the purchasing price, is a source of loss that every progressive management seeks to eliminate. For this reason, the requirements of some commercial engineering departments are very stringent, though considering modern demands and needs, it cannot be said that they are anything but fair.

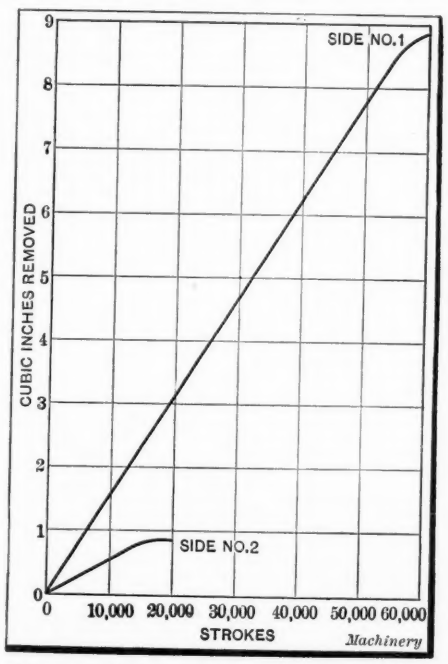


Fig. 1. Difference of 11 : 1 between Durability of the Two Sides of a File

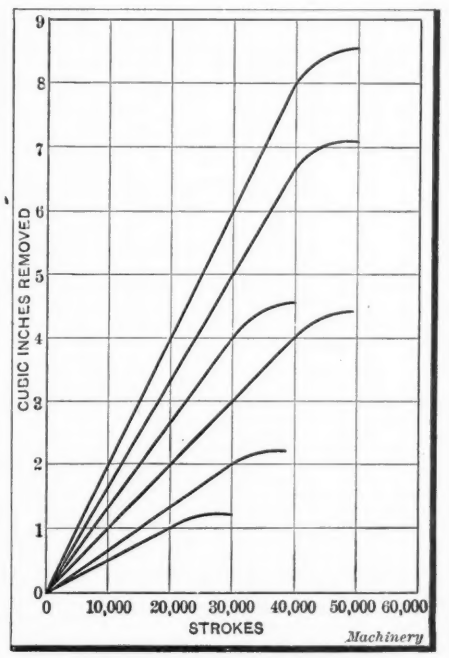


Fig. 2. Typical Curves obtained from File Testing Machine Recorder

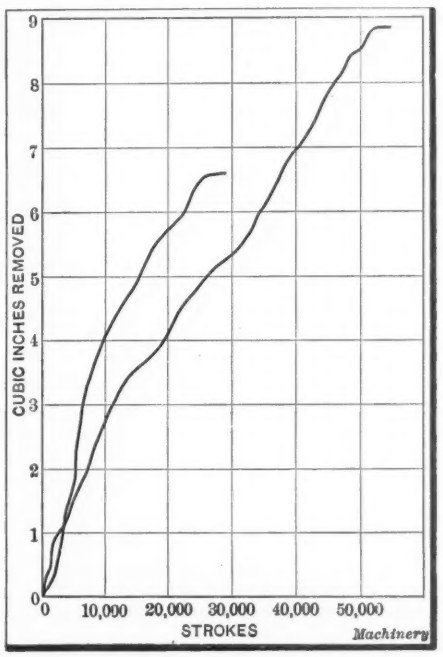


Fig. 3. Abnormal Curves showing no Dependence upon an Operating Law

Of the latest engineering materials and tools to come within the scope of standard commercial tests, one of the most important is the ordinary file, of which it is no exaggeration to say that tens of thousands are made, used, and worn out every year. Now in every file-manufacturing works, it has been the practice to test each file for sharpness by means of a "prover" before it is passed. A prover is nothing more nor less than a short piece of comparatively soft steel which is drawn over the face of the file by hand. If the prover drags as it is being drawn over the face of the file, the latter is passed; whilst if it slips too easily, it shows that the file is not cutting properly, and such files are rejected. This method of testing files, which in the hands of an experienced operator may produce fairly reliable results, is not entirely satisfactory because it depends too much upon the judgment of the workman for its results. Everyone knows that personal judgment is a variable quantity, and likely, therefore, to lead to variable results. In engineering works where files are used, the old-fashioned method of testing files—and one still in vogue in quite a large number of such establishments—consists of distributing files of the brands that are to be compared among a number of reliable workmen, with the order to try them on the materials ordinarily worked on in the shops and report as to the order of merit of the different brands. These reports express each man's judgment and form the basis of the decision of the purchasing department as to the brand to be finally selected when issuing orders for the files. This is not, however, a very reliable method of testing files, as it is a notorious fact that workmen can become so accustomed to the use of one brand of file, that even when called upon to choose between two or more brands, they will select the brand that they are used to—which they discover in some subtle manner—whether, in their honest opinion, that brand is better than the others or not. This is, of course, evidence of the conservatism of man.

Early History of Mechanical File Testing

Until the advent of the mechanical method of testing files embodied in the Herbert file-testing machine some five or six years ago, the above methods—each in its own sphere—were regarded as being the only two methods of testing files which were available—though a mechanical file tester has existed in a very crude form for something like twenty years. Mechanical file-testing can be adopted by both file manufacturers and file users—the former for the purpose of improving the cutting and wearing qualities of their products: the latter for the purpose of comparing files of different brands and also files of any one brand against the standard, in their effort to get the best that are available at the price.

The history of the mechanical testing of files, although so brief, is one in which conservatism and opposing interests have played a very large part. It is certain, however, that every manufacturer of high-grade files is now quite prepared to allow his products to be submitted to a mechanical test, provided the conditions of the test command his complete confidence. On the other hand, it is quite as certain that he will not willingly submit his products to a test in which he believes there is a considerable element of doubt as to the fairness and accuracy of the results. Consequently, it is of the utmost importance that the file test imposed should be one which commands the confidence of every one concerned—whether file manufacturer or file user. Care should be taken in applying the test to see that uniform conditions are maintained, and that the truth respecting any file is not masked by outside influences brought to bear on the machine or test. The Herbert file-testing machine was described in detail in the

* For further information on file making and file testing, see "Manufacturing The Vixen File," September, 1912, and other articles there referred to.

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December, 1907, issue of MACHINERY. The results of tests made with this machine have been subjected to a tremendous amount of both favorable and adverse comment, on the part of file manufacturers and file users alike, though more especially the former. The reason why file manufacturers were and in many cases are still opposed to the use of the Herbert file-testing machine, for the purpose of determining the cutting qualities of their files and comparing them with a standard, has been because many of the results forthcoming were inexplicable and appeared to be contradictory. Thus, files which both manufacturers and users have regarded as being of the very best quality have given extremely poor results in the Herbert file-testing machine. In many cases, great differences in cutting power and durability are reported to have been discovered, by means of this machine, between the two sides of one and the same file. Similarly, files of the same grade and make have shown great variation, even when the utmost care has been taken in the process of manufacture to eliminate differences and to produce files similar in every respect. According to tests made on this machine, differences between the two sides of a file as great as 30:1 have been reported, while a difference of from 4:1 to 10:1 is by no means uncommon, even amongst the very best brands of files. Fig. 1 shows a difference of 11:1. Under ordinary circumstances of manufacture, it is not feasible to suppose that such huge differences can possibly exist, and it is these extraordinary results that have shaken the confidence of file manufacturers in the reliability of the results produced by file-testing machines.

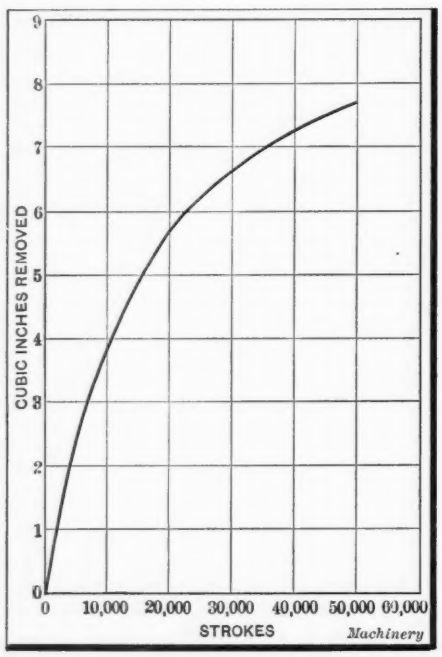

Fig. 4. Diagram showing Gradual Blunting of Files

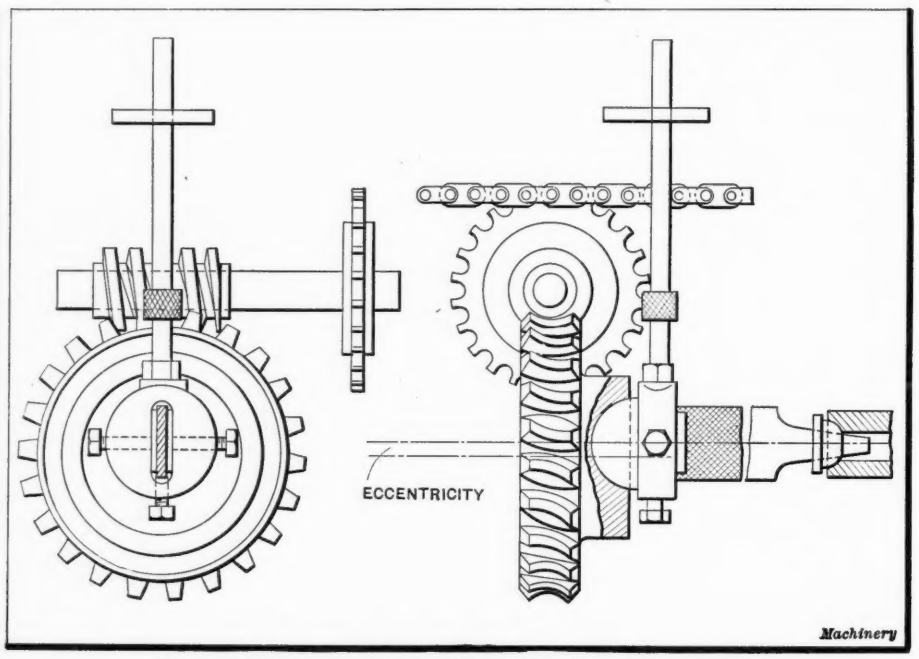

Fig. 5. Mechanism for changing Relative Position of File and Work

There is, however, a real demand for a mechanical file test, notwithstanding the opposition of file manufacturers and others. The file-testing machine, in one form or another, has come to stay, and it will sooner or later be recognized as a necessity in the domain of engineering testing, where it will be used in connection with all large contracts for files. With this idea in mind, the subject of mechanical file-testing has been investigated during the past three or four years by Dr. W. Ripper and the writer in the laboratories of the Applied Science Department of the University of Sheffield, where a Herbert file-testing machine has been installed and thoroughly examined, together with the results which have been obtained from it. The method of procedure followed with this machine is briefly given: The file to be tested is held rigidly between two headstocks, which are carried on a reciprocating table. The test bar is supported on grooved rollers, in a horizontal position normal to the direction of motion of the table and file, and is pressed against the face of the file by means of a rope and weight. The movement of the file over the end of the bar causes a portion of the metal to be removed at each cutting stroke, the amount depending upon the composition of the material of the bar and the cutting power of the file under test. The file cuts on the forward stroke only. At the end of this stroke, the bar is drawn a short distance from the file by means of a clutch mechanism. This condition is maintained throughout the backward stroke, at the end of which the bar is released and allowed to come again into contact with the face of the file. The pressure of contact is 30 pounds per square inch, since the cross-sectional area of the bar is one square inch and the weight is one of 30 pounds. This pressure is maintained throughout the cutting stroke, the length of which can be varied to suit the conditions. To prevent chattering and jarring, and undue deflection of the file, heavy weights are supported on a rest which is carried by one of the reciprocating headstocks, these weights pressing on the back of the file. A recording apparatus is attached to the machine, the number of cutting strokes made and the number of cubic inches of the bar filed away, up to any time after the beginning of the test, being instantly obtainable from the curve which is automatically produced.

Cause of Errors in Mechanical File Tests

The early experiences of Dr. Ripper and the writer led them to believe that this machine possessed one or two defects, to determine the exact character of which, repeated and extended experiments were made. In the first series of experiments, only the best files of well-known makers were tested, the object being to eliminate, as far as possible, all outside influences upon the results of the tests. The results of the tests were quite normal in some cases, but in the majority of the cases, extraordinary and unaccountable differences of effectiveness or cutting power appeared to exist, both between files of the same batch and between the two sides of the same file. On examining the diagrams obtained from the machine during the tests, and also diagrams obtained from other machines, it was impossible to fail to notice at least two points in regard to their unusual character. The first point to be observed was the peculiar shape of each curve, this giving no evidence of the existence of an operating law. Two general forms of diagram or curve were discovered. The first, examples of which are shown in Fig. 2, is the more usual; the lower section is practically a straight inclined line, with a very slight curve at its upper end turning it into the horizontal. The other form is a zigzag line, examples of which are represented in Fig. 3; these diagrams show no signs of regularity and appear to contradict every mechanical law likely to operate in such a case as this. The second point to be observed was the great apparent difference in cutting capacities, which were found by means of this machine to exist between files belonging to the same batch, and between the two sides of the same file. In regard to the first point, we shall have to consider the nature of the file, and

the action of the machine upon it, to discover whether such curves are reasonable or not. In some quarters, the file is regarded as a cutting tool which works on the wedge principle, though in essence, its action is more like that of a scraper. Its teeth are small projections, which in the case of a new file, should have sharp edges. These teeth are capable of being pressed more or less into the end of the test bar under the influence of the weight of 30 pounds. The initial cutting capacities of these teeth depend almost entirely—other things being equal—upon their sharpness, and the depth that they are caused to penetrate in the end of the bar. From the very beginning of the test, the influence of the bar upon the teeth of the file is in the direction of blunting them, so that as the test proceeds, the teeth become blunter and blunter. Accompanying this condition, there is a reduction in the depth of penetration of the teeth in the bar, although the pressure upon the file per square inch of bar surface remains constant. This reduction is due to the increase in the area of the flats on the teeth.

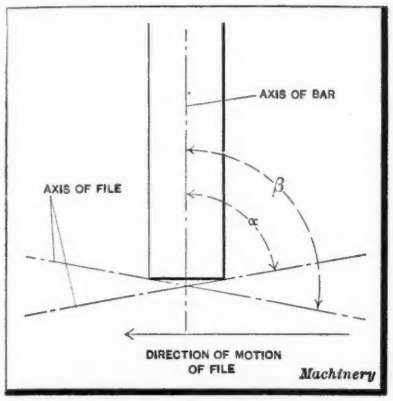

Fig. 6. Diagram showing Influence of Position of File on its Ability to cut

From the foregoing, it would seem to be fairly obvious that as the test proceeds, the rate of cutting should show signs of falling off, this being indicated in the diagram Fig. 4 by a curve, having a tangential tendency towards the horizontal which increases as the test proceeds. Under these circumstances, it is almost impossible to conceive the teeth of such a tool as the file retaining their original sharpness until the end of the test is nearly reached, and then suddenly ceasing to cut without any intermediate condition of cumulative bluntness. The irregular curves appear to be entirely beyond the ingenuity of man to explain in any reasonable and acceptable manner. In the course of the experiments already referred to, it was discovered that the cutting power of the side of a file, as indicated on the chart of the machine, was affected in no inconsiderable manner by the position of the file between the headstock, and by the relation of the axis of the file to the axis of the test bar. Thus, in practically every case which came under the notice of the writer in making these tests, the file would not cut at all if it was presented to the bar so that the angle between the axes of the file and the test bar on the leading side of the latter, as indicated by β in Fig. 6, was greater than 90 degrees; if the angle was reduced so as to be less than 90 degrees, as shown at α in Fig. 6, it would generally commence to cut. It was also discovered that the exact value of the angle between the two axes determined the rate of cutting, to a certain extent, the angle corresponding to the best position of cutting for one file not, necessarily, being the same as the corresponding angle for another file, although in most of the cases the differences were very slight. These differences, however, were sufficient to affect the results materially. It was found that the limiting angular positions of the file, for maximum cutting powers, were those in which the point end of the file axis was 1/32 inch and 5/32 inch, respectively, beyond the heel end, these measurements being made in a direction parallel to the axis of the bar and normal to the direction of motion of the file.

From a consideration of this subject, it will be seen at once that since there is such a wide diversity, it is impossible to select the best cutting position of the file in any particular case; it can only be accomplished by sheer accident. This partly accounts for the wide apparent differences in the cutting capabilities of approximately equal files. As the result of a further examination of the machine, it appeared that the mechanical action differed materially from the action of hand filing. The machine, as originally designed, holds the file so rigidly that it moves across the end of the test bar in an absolutely constant and unchanging path, while in the case of hand filing, the path of the file is changed more or less at every stroke. Therefore, the conditions of a mechanical test made on this machine differ from those which obtain when the file is used in actual practice, the result of maintaining a constant direction of motion being the formation of grooves in the end of the bar, the glazing of the face of the file, and the refusal of the latter to cut, even though it may not be worn out. To eliminate these defects in the action of the machine, Dr. Ripper and the writer designed and constructed a mechanism which, when added to the machine, removes the condition of constancy in the direction of motion of the file and its attendant influence upon the results, and causes the file to pass through a number of different angular positions with respect to the test bar, between the two extreme best cutting positions for all files as referred to above. At the same time, files of the same kind and size are treated in exactly the same way, so that the conditions of the test are maintained constant. By this means, the grooving of the end of the test bar by the teeth of the file is prevented, and each file is caused to give an average result for all the positions occupied. There are forty-eight of these positions in a complete cycle; at least one of these, and in the majority of cases two, is the best cutting position. The result obtained by the improved machine is the average cutting power of the file, and not its

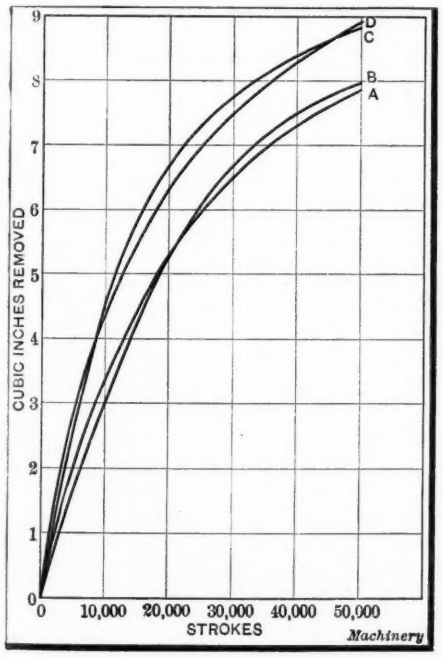

Fig. 7. Curves for Sides of Two Files of the Same Make

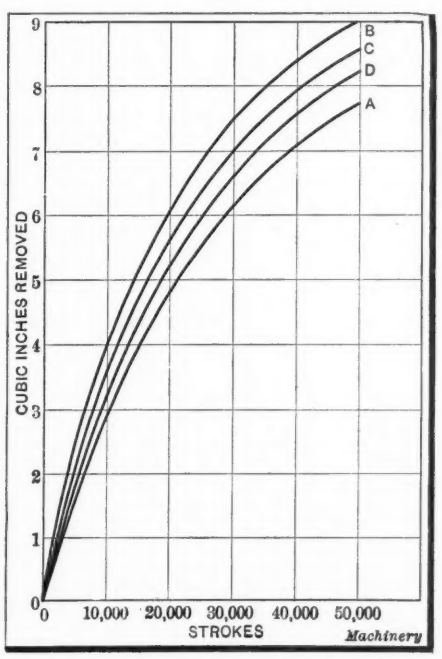

Fig. 8. Curves for Sides of Two Files that are all of the Same General Order

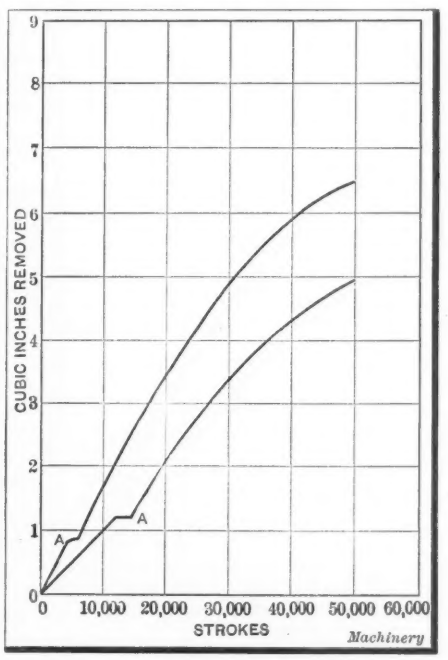

Fig. 9. Effect of changing Position on Durability of File

best or worst cutting power. Thus the results of all tests when this mechanism is used—provided, of course, that the other conditions of the test are maintained constant—are comparable with each other.

Mechanism of the Improved File Testing Machine

The mechanism by means of which this movement of the file is accomplished, is shown in Fig. 5. It consists of two ball-and-socket connections between the two ends of the file and the headstocks. The socket at the heel and tang end of the file is fixed in its headstock, while the other socket is arranged so that its center has a slight rotary movement, which is transmitted through the ball to the point end of the file. In this circular path, there are forty-eight different positions which are equally spaced, and these positions are occupied by the point end of the file during successive cutting strokes. The radius of the circular movement at this end of the file is 1/16 inch. The rotating socket is formed in the boss of a worm-wheel, which is mounted on the headstock, but set eccentric with it, as shown, the eccentricity being 1/16 inch. The worm-wheel is driven by a worm that is mounted on a plain shaft, the outer end of which carries a free sprocket wheel. The chain which meshes with this wheel is fastened to two fixed points on the frame of the machine. By this means, the sprocket wheel, having the same reciprocating motion as the table and file, is caused to rotate through its engagement with the fixed chain. This rotation is transmitted to the worm-wheel and ball-socket during the return or non-cutting stroke. During the cutting stroke, the sprocket wheel is traveling in the other direction and rotates quite freely on its hub, which is keyed to the worm-shaft; during this stroke the worm-wheel and socket are stationary, and the position of the file is not changed. Consequently, a change in the position of the file is made for each double stroke, and during each cutting stroke the file is presented to the end of the bar in a slightly different position from that occupied by it during the preceding strokes. There are forty-eight different positions in a complete cycle and the time required to complete a cycle is just under one minute, since the machine makes fifty double strokes per minute in its original form.

The point of the file is secured in the ball-holder by means of four set-screws and two small steel wedges. One of these set-screws is extended and attached to a bent arm, which rests on the reciprocating table and travels with it. This prevents the file from rotating on its own axis, as it would have a tendency to do if secured too firmly between the two headstocks. The wedges were found necessary to bring the point of the file exactly in the middle of the slot in the face of the ball. The tang of the file is inserted in a small ball holder which rests in the cupped end of adjusting screw of the headstock. This screw is longer than the one which is usually supplied with the machine, an additional nut being used on the other side of the headstock boss to get delicate adjustment of the file between the two headstocks. For files of different lengths, eccentricities of different amounts may be used, but this is hardly necessary—though some regard it so—because, in practice, it is not generally required to compare files of different lengths, so much as different files of the same length and grade. If desired, the pitch of the worm and wheel could be made different from that selected in connection with the original design, so as to obtain a cycle of positions of greater or less duration than one minute. It should be observed that the face of the file presented to the bar is not, except in two positions at the most, vertical; these two are the extreme inner and outer positions. In all other positions, the face of the file is more or less inclined to the vertical, the inclination being in one direction for half of the positions and in the other direction for the other half.

Conclusion Drawn from Carefully Conducted Mechanical Tests

A very large number of tests have been made with this apparatus on all makes and sizes of files. The majority of the results have shown that the defects found in files by the ordinary method of testing do not exist, while in no case do they exist to anything like the same extent that the ordinary test results suggest. The curves obtained by means of this apparatus are of the general character of the representative standard curve shown in Fig. 4. They show the gradual reduction in the cutting capabilities of files during the progress of the test, which can reasonably be expected. Figs. 7 and 8 show representative curves obtained by this method. The curves *A* and *B*, in each figure, represent the two sides of one file, the curves *C* and *D* representing those of another file of the same make. The two figures represent two different makes. It will be observed in Fig. 7 that there is very little difference between the two sides of each file, in a test whose length is 50,000 strokes, although it will be seen that in neither case are the two curves of exactly the same order, since they intersect, the first in one place, and the second in two. In Fig. 8, all the curves are of somewhat the same order there being no intersection of the pairs. There is, however, a greater difference between curves *A* and *B* than between curves *C* and *D*, based on a test of 50,000 strokes. On the other hand, the difference between the two files represented by Fig. 7 is greater than that represented in Fig. 8.

The results of tests extending over a very long period indicate that such differences as 30 to 1, or 10 to 1, or even 4 to 1 do not exist. The ratios commonly found range from 1 to 1 to 1.20 to 1. Other experiments with this method of testing have produced results which show conclusively that, in the case of a new file, every one of the forty-eight positions of the file has a corresponding cutting power. This cutting power is usually different for each position, so that the test invariably gives an average result, which is a much fairer result than any other. A number of experiments have also been made to determine the effect of the application of this varying position principle in cases where, according to the ordinary test, files were worn out—that is, had ceased to cut in the machine. The result was conclusive in every case; at the same time, it was astounding. Fig. 9 represents the results graphically. In the case of each curve, the point *A* is the break-down point, where, in the ordinary test, the file ceases to cut. By putting the position-changing apparatus into action, each side was caused to start cutting, and to continue cutting so that the file did not actually give out at the end of 50,000 strokes. From the results of many tests, of which the above are samples, it is felt that this apparatus supplies a much needed element to the test, and enables both file manufacturers and users to repose greater confidence in the results of the tests than has hitherto been the case.

In conclusion, and as an apposite addendum to the above, it may be pointed out that the exact chemical composition and physical properties of the test bar have a considerable influence upon the results of the tests. As there does not appear to be a test bar which is universally recognized and employed as *the* standard, it cannot be said that the conditions of file-testing are in a very healthy state. To demonstrate the fact that the influence of the physical properties of the test bar is no inconsiderable factor in the problem of file-testing, some tests were made with two similar files from the same batch on two test bars, one having a Brinell hardness numeral of 241 and the other of 186. Each file made 20,000 strokes, in which only 2.75 cubic inches of the hard bar was removed by one as against 6.25 cubic inches of the other. This is conclusive evidence that for a *standard* test there should be a *standard* test bar.

* * *

Near the old sun temple at Baalbec, in Syria, there is an enormous cut stone, probably the largest cut and finished piece of stone in the world. It is about 72 feet long, 13 feet wide, and 16.5 feet high. It is believed that the stone was intended for the sun temple which is now in ruins. There are still in the heavy walls of this temple stones of similar dimensions. Several that have been measured are about 66 feet long. These stones are placed in the wall at a height of nearly 20 feet above the ground. No indication of mortar can be detected, but the stones are so carefully cut and polished on the surface that it is only with difficulty that the joints can be detected. In fact they join so closely that a thin knife edge will not enter between them. How these blocks of stone could be lifted to such a height, and how buildings of this type could be erected, is one of the secrets of a past age of engineering.

SOME GOOD RESULTS OBTAINED BY THE BONUS PLAN

BY W. L. MYLES*

Much has been said and written regarding the advantages and disadvantages to both employer and employe of the bonus or premium plan of pay. Men who have given this plan a fair trial have attributed credit to it for obtaining lower manufacturing costs and higher factory efficiency for the employer, and higher wages for the employe. On the other hand, the bonus plan has been subjected to some hard criticism, principally by those who have never seen it in operation, or by those who are entirely unacquainted with its fundamental principles and ability to produce results.

Speaking from an experience of five years with the bonus plan, the writer believes that it is one of the best systems,

PART NO. F'E1

Bore 2nd Ream two holes
Face top 2nd bottom
of 8 HP
Cylinder Casting

Job to be machined on No 16 Mill
Job Rate 33¢

Time Allowed Per Piece	Day's Wage Per Piece	Cost Per Piece	Bonus Hour Rate
150 Min	825	825	33
140 "	.77	.798	.344
130 "	.715	.754	.36
120 "	.66	.714	.38
110 "	.61	.693	.402
100 "	.55	.666	.43

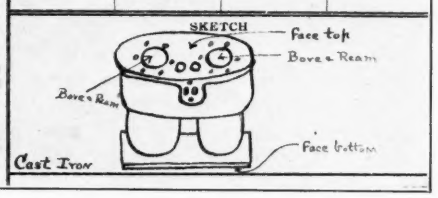

Fig. 1. Rate Card, showing Time allowed per Piece and Rate paid per Hour—4 by 6 inches

if not the best system, now in vogue, for justly compensating the workman for the extra effort he puts forth. This plan is also instrumental in obtaining those results so earnestly sought by the manufacturer or employer, *viz:* lower costs and greater efficiency of production. One of the advantages of the bonus plan is that it justly rewards the mechanic for extra effort; it creates a spirit of cooperation which would not exist under other conditions, and lifts the mechanic and the shop to a higher plane of efficiency. This will amply repay

Part No. F'E1 — Order No. 19184

Bonus Card

Draw No.

Mechanic No. 82 Name Geo Barberg

Operation
Bore 2nd face two hole
Face top 2nd bottom
Cylinder Casting of 8 HP

Job Started 9:15 A.M. Mar 28/12
Job Finished 8:45 A.M. Apr. 9-12
No. of Pcs. Finished 44
Guaranteed Wage Rate per Hour regular 33¢
Work Delivered to Stock Room
Allowance none
Inspected by C Johnson

Time allowed per piece		Rate allowed
150	Min.	33 Per Hrs.
140	"	344 " "
130	"	36 " "
120	"	38 " "
110	"	402 " "
100	"	43 " "

Form 101.

Fig. 3. Bonus Card, showing Time allowed per Piece, Rate per Hour, and what Operations to perform—4 by 6 inches

the employer for its installation. Under the bonus plan, the mechanic realizes that the management is interested in him, and he knows that if he gives an honest day's work he will receive an honest day's pay. The amount of that day's pay is entirely in his own hands, for the more work he turns out in a given time, the more pay he receives. This system teaches him that the ability to turn out more work in a day does not require a greater amount of physical exertion, but less, for by following the methods outlined on his instruction card, he uses a little more brain energy and less physical energy to produce the same amount of work. Some of the critics of this system have claimed that it is unfair to the mechanic, as it makes a mechanical tool out of him, rendering him an object for the scrap pile in a short time. It has

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been proved, however, to the satisfaction of these critics, that this is entirely wrong. The tendency of this system is to awaken the mechanic out of that dreamy mechanical state in which many of our workmen are today, into new, energetic men; for, in order to earn their bonuses, they realize that they have to use their brains and hands at the same time, thereby avoiding many mistakes and accidents. The reward of extra compensation is sufficient to repay the mechanic for his extra effort which, in a great majority of cases, is but a matter of giving a little more thought and attention to his work, reducing instead of increasing the physical effort formerly employed. It is a known fact that 90 per cent of the workmen of this country are accomplishing less than 60 per cent of what they might do without physical injury or over-exertion.

Under the bonus system, in one shop the writer has in

TIME STUDY — Wife

No. 82 Name Leo Sachrag Rate 33

Machine No. 16 Kind Horiz. Boring Mill

	Time Taken
Setting up —	30 Min
Face & finish, one cut —	25 " 20 Sec
Change tool & grind cutter —	17 " 10 "
Lay out castings —	3 "
Adjusting cutters —	10 "
Bore one hole —	24 " 30 "
Change to reaming tool —	3 "
Ream one hole —	6 " 30 "
Change to boring bar —	20 "
Bore one hole —	24 " 30 "
Change to reamer —	3 "
Ream one hole —	6 " 30 "
Take out of Machine —	2 " 43 "
Clean out Chips —	2 "
Total time	178 min 13 sec

Speed - 40 feet per min
Feed - 1/8 to 1/4"

Note — Time taken when done on Day's work = 5 hrs 30 min

Fig. 2. Detailed Record of Results of a Typical Time Study, on Back of Rate Card

mind, the men are doing 40 per cent more work with about 25 per cent less physical effort. Why is this? Partly because the management has standardized the tools and equipment, and provided the mechanics with instruction cards which show exactly how the work should be done, thus eliminating many unnecessary moves. But it is mainly because the bonus offered is large enough to supply the needed incentive. Many have asked the question, "Do the majority of those working under the bonus plan earn bonuses, or is it only those who

Record — 80½ hrs

No. of Hours on Job	
Credit for	
Total Time	
No. of Finished P's.	44
Total Prem.	3 hrs 3
No. Part Finished	✓
Time per Pce.	110 Min
Labor Cost per Pce.	$ .58
Shop Cost " "	.465
Prem. " "	.11
Total Cost per Pce.	$ 1.155

Note — Previous cost on day's work
5½ hrs. @ 30¢ = 1.65
Shop Expense = 1.32
= 2.97

Fig. 4. Cost Record of the Operation, on Back of Card, filed for Future Reference

are most rapid and experienced in their particular line?" The writer can readily answer this question by referring to a chart kept by him, which shows the percentage of each class of workmen that earned bonuses. For the first three months of the present year, over 75 per cent of the men earned bonuses which gave them an average increase of 8.5 cents per hour, or about 30 per cent higher wages. Through the opportunities offered by this system for men to show their ability in mechanical lines, laborers and helpers have turned out to be good mechanics, and mechanics have become functional foremen, thereby increasing their earning power and adding materially to the efficiency of the plant.

The following is a general outline of the procedure followed in making time studies, setting rates, and issuing bonus cards, together with forms used by one of the leading manufacturing

concerns of New Jersey, which has operated this plan successfully for some years. In order to correctly set a time and price on a piece of work, it is necessary to know each operation and move needed to complete the work in the shortest and best way. When a job is to be put on bonus, a detailed time study is made; the machine best suited for the operation is next decided upon, correct tools are supplied, and belts and equipment are brought up to proper speed. Each operation is timed separately with a stop watch; then an overall time is taken to verify it, a fair amount of time being allowed for grinding tools, etc. Fig. 1 shows a form of rate card, giving the time allowed per piece and the rate paid per hour. On the back of the rate card, there is a record of the detailed time study. It will be seen that decreasing the time per piece increases the rate paid per hour. After the time study is complete, a bonus card is issued to the mechanic to start with the work. This form includes the time allowed per piece and the rate paid per hour, also what operations to perform, the time of starting and finishing job, the part number, etc. A cost record of the operation is kept on the back of the bonus card, which is filed away for future reference.

The men are guaranteed their regular day's pay, whether they make the pieces in the allotted time or not. When the job is finished, the time of finishing is stamped on the card and the number of pieces is recorded; the card is then taken to the foreman, who verifies the number of pieces and inspects the work, if no regular inspector is employed. The finishing time of the last job is always the starting time of the next job, except where special time is allowed for repairs or some other necessary work, other than the general up-keep of the machine. This eliminates a large amount of time that was formerly lost between jobs, when done under the old day-work system. The foreman's task of answering a lot of unnecessary questions, and standing over a man in order to keep him at work is reduced 50 per cent, as the instruction card states plainly what is to be done and all other information that is required on the job. Needless to say, the men working under the bonus system require no watching; all their time and attention is required for their work, if they wish to earn their bonuses.

Some of the results obtained by working men on the bonus plan of pay can be summed up as follows: Higher wages and greater efficiency for the mechanic. A reduction of the number of accidents, for many an accident is caused by inattention to work. A method of showing the foremen who are the non-producers or "deadheads" in their departments. A reduction of the "overhead" expenses of the plant. Simplification of the method of keeping costs and the production of far more accurate cost records. A reduction in the cost of manufacturing, and a marked increase in output. In general, the bonus plan benefits all parties concerned and compensates the mechanic as no other system can. For the greater effort put forth by both employer and employe, a material increase in efficiency is seen throughout the whole plant, and in addition, there is that spirit of cooperation between both parties that is so essential to a successful business.

* * *

IMPROVED TYPE OF COUPLING BOLTS

A recent number of *Page's Weekly* describes a practical type of coupling bolt which was designed to do away with the difficulty experienced in extracting the bolts when it is necessary to disconnect a shaft. The advantage of such a design will be apparent to any sea-going engineer who has had experience with broken shafts at sea. According to the writer the corrosive action of salt water upon ordinary steel is such that he has known it to take a week to get out twenty-four three-inch bolts, while the same work can be done in an hour where the improved type is in use. Figs. 2 and 3 show cross-section views of coupling flanges connected with the old style bolts. These two types are identical, with the exception that a head is provided on the bolt shown in Fig. 2, while the type shown in Fig. 3 depends entirely upon the taper for holding it in the flange. Both of these bolts are made of steel. Fig. 1 shows the improved type of bolt previously referred to. In this case it will be seen that the regular nut is provided at one end for tightening the bolt, while a similar nut is provided at the opposite end for drawing the bolt when it becomes necessary to disconnect the shaft. The nut *B* used to tighten the bolt, is best made of "Delta" metal or some similar tenacious metal of a non-corrosive nature, and washer *C* is of similar material. The nut *D* used for starting the bolt is made of non-corrosive "Sceptre" bronze with a washer of similar material. Before putting the bolt in place, it is thoroughly coated with a mixture of flake graphite and castor oil which further protects from corrosion.

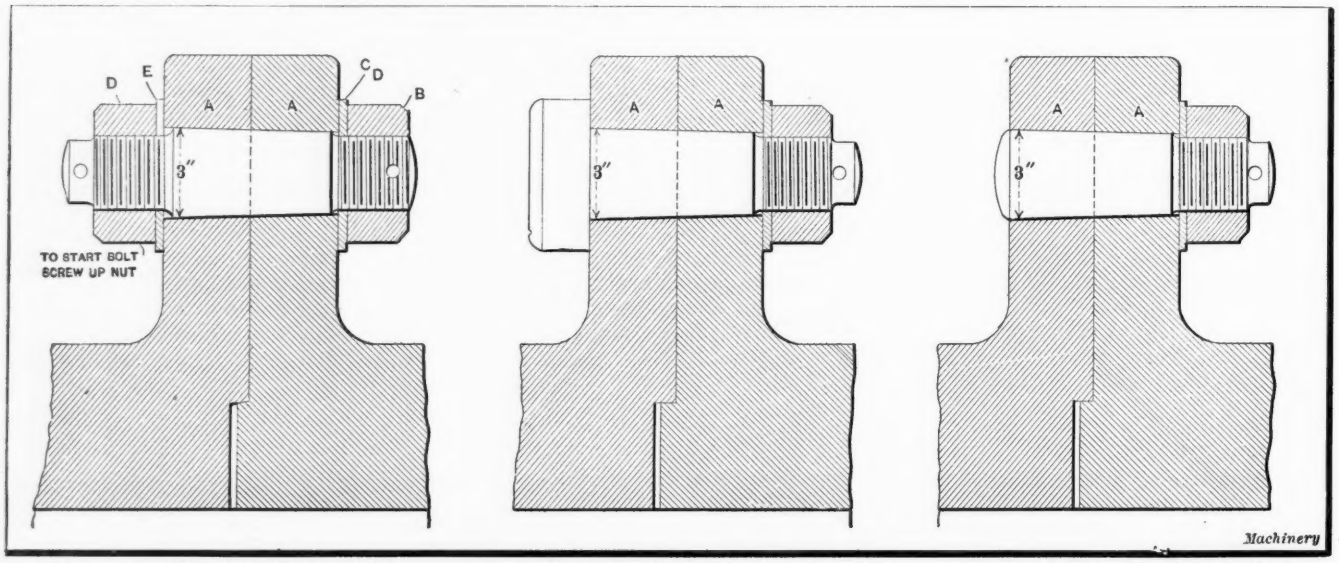

Fig. 1. New Style Bolt with Second Nut for Starting

Fig. 2. Old Style of Bolt shown in Fig. 3, with a Steel Head

Fig. 3. Old Style Bolt with Steel Nut, Washer and Pin

* * *

"EXPLOSION-PROOF" ELECTRIC MOTORS

The United States Bureau of Mines, Washington, D. C., has issued a bulletin (No. 46) regarding the results of an investigation of explosion-proof electric motors. The term "explosion-proof" as applied to an electric motor refers to a motor enclosed by a casing so constructed that an explosion of a mixture of mine gas (methane) and air within the casing, will not ignite a mixture of the same gas surrounding the motor. There are two classes of motors so constructed: First a class totally enclosed and built strong enough to withstand internal explosion pressures and so designed that the efficiency of all the enclosing covers can be satisfactorily maintained; second, a class provided with relief openings or valves designed to cool any products of combustion discharged through the valves. The results of tests are given in detail in the bulletin. These tests are of interest to other than mine operators, as explosion-proof motors are desirable in situations such as flour mills and other plants in which explosive gases incident to the processes of manufacturing sometimes collect.

EVOLUTION OF A SKYSCRAPER

In a paper entitled the "Evolution of a Skyscraper," read before the American Society of Swedish Engineers, 271 Hicks St., Brooklyn, N. Y., November 2, 1912, Mr. N. L. Malmros made reference to some antiquated provisions that are still part of the building laws of New York City, and which indicate how difficult it is for the law-making bodies to keep pace with the advances in science and engineering. The building law of New York City contains provisions which were unsuitable and unnecessary even twenty-five years ago. One of these provisions is that relating to wall thicknesses, which works a hardship and an actual disadvantage from all points of view in the erection of high buildings. The modern steel skeleton structure does not depend on the masonry walls for support; instead the steel frame supports and holds the masonry in position. The function of the walls is principally to afford protection against the weather and fire, and as the walls are carried entirely by the steel framing at every story, their thickness need be no greater at the bottom than at the top. Nevertheless, the building laws at present in force in New York City require as great a thickness of wall in the lower stories as though they actually carried the weight of the building. As an example, it may be mentioned that a building one thousand feet high would have walls six feet thick at the ground floor. The unpierced walls along the lot lines facing adjoining buildings would have to be solidly made of this thickness for several stories up. This involves not only a waste of rentable space but places an enormous dead load on the steel structure and on the foundations—a load which detracts rather than adds to the strength and safety of the building construction. Strong efforts have been made within the past two years to frame a suitable and sane building code, but these attempts have all failed by reason of the conflicting and warring interests within the building material industries.

Mr. Malmros mentioned that he expected to see still higher buildings in New York City than the Woolworth building now nearing completion, which is about 750 feet high. He mentioned that he had been connected with the design of a proposed building 1100 feet high, of about eighty stories, which careful calculations showed, would have proved a good investment. The limiting factor in high buildings is the transportation facilities within them, and the large space taken up for elevators, halls and stairways, which require a proportionately larger space the higher the building is made. As far as the steel construction is concerned, there is no reason why a building 2000 feet high could not be erected.

Reference was made to the Singer Building, of which Mr. Malmros, acting in a consulting capacity with Ernest Flagg, was the architect. As an interesting illustration of the great amount of work connected with the building of a skyscraper of this type, it may be mentioned that the specifications covered more than eight hundred typewritten pages, and that the number of trades employed in the building of this structure, for which separate contracts were let, numbered more than seventy-five. About 1500 drawings were made in the architect's office for this building, besides all the shop and construction drawings made by the various contractors, which were also checked and corrected in the architect's office. A peculiarity of the very high building is that on account of the enormous wind pressure to which it is exposed, and its proportionately small base, it must not merely be placed upon its foundation but must be actually anchored down very securely.

* * *

A pressure of from four to thirty-five pounds per square inch of surface on work being ground on a disk wheel is recommended by the Gardner Machine Co., which has experimented extensively in determining the proper pressures for grinding. A less pressure than four pounds per square inch results in polishing and burnishing the work. For this reason it is necessary, when grinding light pieces on a horizontal disk wheel, to load them with weights when the weight of the piece does not impose a pressure of more than four pounds per square inch.

TURNING ELLIPSES IN THE LATHE

BY GEORGE E. POPE*

The writer believes that the following method of turning an ellipse in a lathe has not found wide application for two reasons: it will be evident from the description that it has a rather limited scope, and the principle has probably never occurred to a great many men. The possibility of applying this method is controlled by several considerations, *i. e.*, the

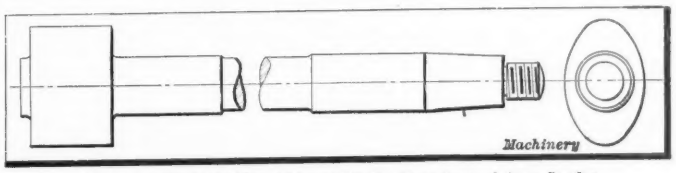

Fig. 1. Elliptical Emergency Brake Cam turned in a Lathe

length of the ellipse to be turned must be comparatively short, it must be on the end of a shaft, pin, or similar part, and the ratio of the major to the minor axis must not be too great. These conditions are all met with in the case of the emergency brake cam shown in Fig. 1. The design of this cam was changed from one whose section is shown in Fig. 2; this illustration also shows the method of milling with a formed cutter, the cam being milled on one side and then turned over to have the other side formed.

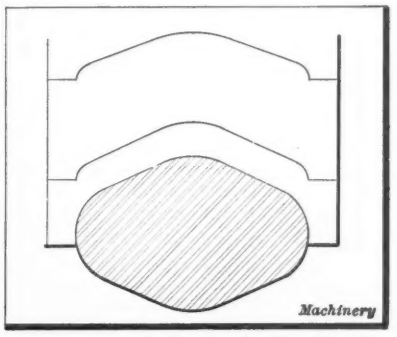

Fig. 2. Former Type of Cam produced by Formed Cutter

In Figs. 3 and 4 are shown a plan view, a partial side view, and sections of the device for turning this cam in a lathe, after changing its design to an elliptical section. Referring to Fig. 3, the device will be seen to consist in part of a square steel block *A*, that is tongued into and bolted to the faceplate and carries the fly-cutter *C*. The remainder of the device consists of the cast-iron block *B* which is tongued into and bolted to the upper surface of the compound rest of the lathe, as shown plainly in Fig. 4. A bushing *D* carries the cylindrical end of the work which has already been turned to size. This bushing is split through one side and is closed in

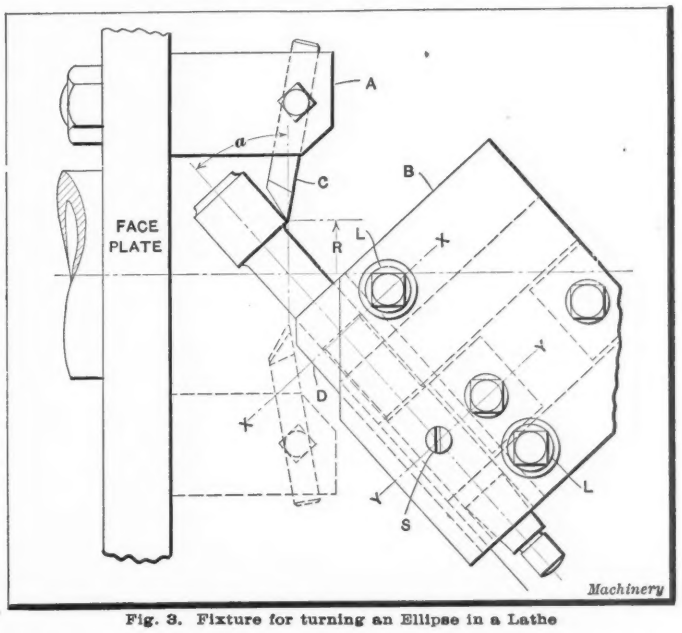

Fig. 3. Fixture for turning an Ellipse in a Lathe

firmly on the work by means of the bushing locks *L;* it is prevented from rotating by the pilot on set-screws *S*. This bushing can easily be replaced by others of different sizes, thus making the fixture adaptable for various sizes of work.

It will be readily seen from Fig. 3 that in order for the elliptical section to be concentric with the shank, the axis

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must pass exactly through the center of the circle generated by the point of the fly-cutter *C*. This is accomplished by taking care that the height *H* in Fig. 4, from the surface of the compound rest to the center of the split bushing, corresponds closely to the height from the surface of the compound rest to the center of the lathe spindle, and by adjusting the longitudinal position of the carriage, taking light cuts over the cam and measuring for concentricity. A positive stop can then be clamped on the ways of the lathe to engage the forward end of the carriage, as the carriage must be moved away from the faceplate in order to remove the finished part.

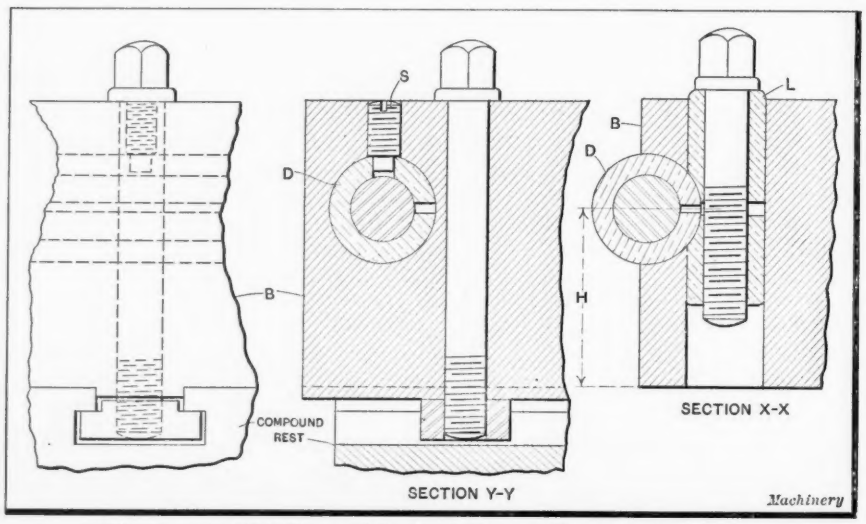


Fig. 4. Partial Side View and Sectional Views of Ellipse Turning Fixture

The compound rest is turned around to an angle *a* which determines the length of the minor axis of the ellipse, and is fed straight in on this angle in the operation of turning the cam. The major axis of the ellipse is determined by the diameter of the circle generated by the cutting point. The angle that determines the minor axis can be readily derived by the method shown in Fig. 5, which is merely the projection of a circle of diameter equal to the length of the major axis of the cam, at an angle sufficient to give an apparent width equal in length to the minor axis. In the triangle *ABC*,

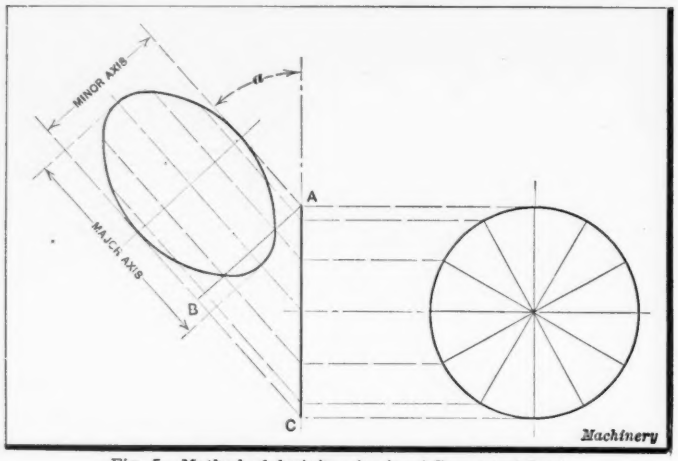


Fig. 5. Method of deriving Angle of Compound Rest

AC is equal to the major axis and *AB* is equal to the minor axis, and the angle *BAC* equals angle *a*. Then $\frac{AB}{AC}$ or $\frac{\text{Minor Axis}}{\text{Major Axis}}$ equals the cosine of the angle to which the compound rest must be revolved for the desired results. This method of turning ellipses could be successfully applied to the turning of the familiar oval locating plugs used in tool work, and for a variety of other classes of work.

* * *

The best all-around aluminum mixture, says a writer in the *Brass World*, is an alloy containing 92 per cent of aluminum and 8 per cent of copper. This mixture casts well, does not crystallize in service or crack in the mold, and has a fair tensile strength.

JOINT MEETING OF THE A. S. M. E. AND V. D. I. IN GERMANY

The plans for the meeting of the American Society of Mechanical Engineers with the Verein deutscher Ingenieure which have been nearly completed, promise the most remarkable tour of the industries in Germany ever offered to American engineers. Conrad Matschoss, Dozent of the Royal Polytechnic High School of Berlin, has been in the United States for several months as representative of the German Society, arranging the details of the tour. The engineers will sail for Germany June 11, and arrive in Hamburg or Bremen June 21, where they will be received by the municipal authorities and given opportunity to visit the great shipyards before going by special trains to Leipzig. There they will be welcomed by the King of Saxony and the municipal authorities of Leipzig.

The party will leave Leipzig June 25, for a tour of industrial Germany visiting the principal cities, such as Dresden, Berlin, Dusseldorf, Cologne, Frankfurt a/M, Nuremberg, Munich, etc. It is expected that the Krupp works will be thrown open to the party and that they will be received by Baroness von Bohler, daughter of the late Herr Krupp.

The final meeting will be held in Munich July 7 in connection with the Museum of Technical Arts of which Dr. von Miller is the director. The itinerary of the society in connection with the fifty-fourth annual meeting of the Verein deutscher Ingenieure, as arranged at present is as follows:

June 21.—Reception at the landing place by the local board.
June 22.—Leipzig, official reception by the Verein deutscher Ingenieure.
June 25.—Dresden.
June 27-28.—Berlin.
June 29.—Dusseldorf—Reception by the Rhine-Westphalian Section of the Verein.
June 30-July 2.—Various functions arranged by the Rhine-Westphalian section, including a trip to Cologne and Essen.
July 3.—Bonn—By boat up the Rhine with festival at Rüdesheim; by rail to Frankfurt a/M., arriving about 6 P. M.; evening reception of welcome at Frankfurt.
July 4.—Independence Day at Frankfurt.
July 5.—Nuremberg.
July 6.—Munich—Evening reception of welcome.
July 7.—Visit to the German Museum.
July 7.—Trip on the Starnberg Lake. Evening—Final exercises in the Pathaus.

* * *

EXPERIMENTAL WORK ON KEROSENE CARBURETERS

What promises to be an investigation of more than usual interest and utility is being conducted by the State Engineering Experiment Station at the Pennsylvania State College, State College, Pa., under the direction of Prof. J. A. Moyer of the mechanical engineering department. With the increase in the price of gasoline has come the demand for some cheaper fuel that will give as good results. Kerosene would meet the demands if a satisfactory carbureter could be designed, and it is with a view of determining the merits and defects of various types of carbureters that the investigation is being carried on. The price of gasoline has nearly doubled in this country in the past year, while in England the price has risen to fifty cents a gallon for "motor spirit." The use of a mixture of gasoline and kerosene has been advocated, but without an efficient carbureter no such mixture can be used. Prof. Moyer has installed at the college a motor built to utilize the energy from either of the two fuels mentioned and suitable for use on farms and country estates. Experiments will also be made on various mixtures, and a carbureter valve will be designed to shift the fuel supply automatically from a small gasoline tank, used only for starting, to the main kerosene tank.

THE ABBOTT BALL-BURNISHING PROCESS

A METHOD OF FINISHING POLISHED WORK BY TUMBLING

BY CHESTER L. LUCAS*

Burnishing, as used in the ordinary sense of the word, consists in finishing exterior surfaces of work by rubbing with a highly polished steel hand tool, which hardens and polishes the surface metal. The Abbott ball-burnishing process produces the same effect, but in an entirely different manner, employing quantities of hardened and polished steel balls which are caused to roll over the work while under pressure. This pressure is effected by the weight of the balls which are confined within a tumbling barrel like that shown in Fig. 2. Thus, each ball acts as an individual burnishing tool, and as it rolls over the work, pressed by the mass of balls and work above, it leaves a burnished path on the work. Fig. 1 shows some representative burnishing jobs which have been efficiently handled by this process. Some idea of the action which takes place within the tumbling barrel may be gathered by noticing the balls and work which are represented in Fig. 3.

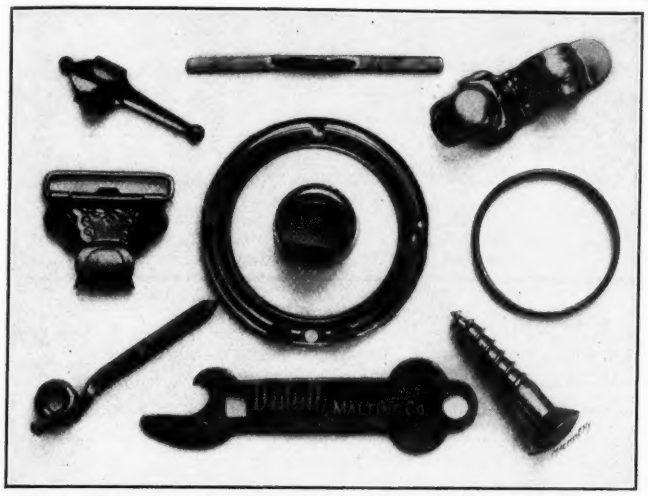


Fig. 1. Character of Work finished by Abbott Ball-burnishing Process

Fig. 4 shows the general form of the ordinary tumbling barrel as contrasted with the Abbott burnishing barrel. From this it will be seen that in the Abbott barrel, the balls are confined in a deep narrow space so that the same amount of balls being restricted within a narrower space exert a heavier burnishing pressure upon the work. The Abbott ball-burnishing process cannot be used when any metal is to be removed or deep scratches are to be taken out. It is purely and simply a burnishing process for putting a high finish upon the work, and on work within its limitations is highly successful. Not only can a large amount of work be done in a short space of time, and in a very efficient manner, but many jobs which cannot be burnished by hand are efficiently finished by this process. Referring to Fig. 3 again, it will be seen that it is a simple matter for the balls to burnish the inside of a tube, the center of a deep depression, or the inside of a wire loop as shown in Fig. 1. Such pieces as these would be difficult to burnish in any other way. In order to burnish corners and depressions, it is necessary to employ balls small enough to come in contact with the surfaces of such places; therefore, on other than the very plainest of work, two sizes of balls are commonly used as shown in Fig. 3. Again, on work which is lettered, ordinary polishing processes "drag" the letters, but with the ball-burnishing process, this trouble is not experienced.

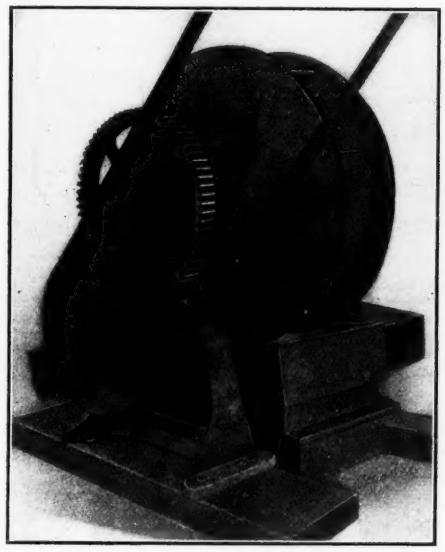


Fig. 2. Type of Burnishing Barrel used

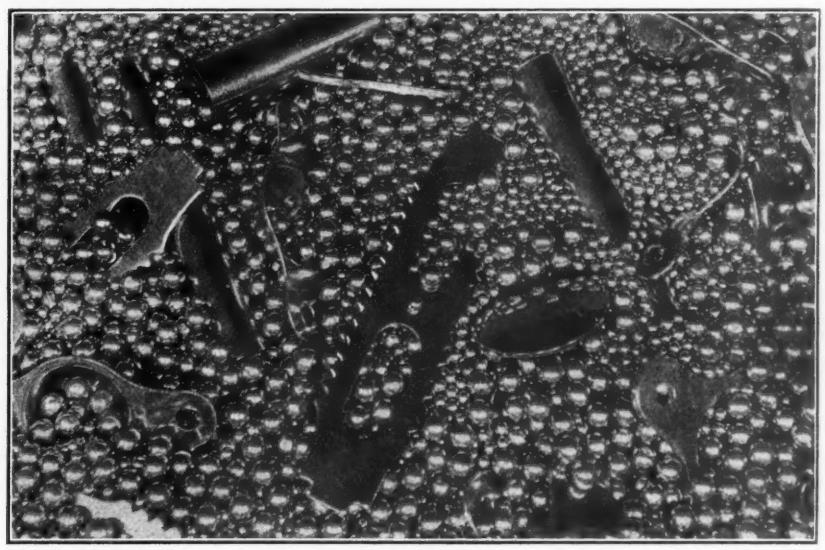


Fig. 3. View within the Barrel to show Burnishing Action of the Balls

The balls used for this work are made of low carbon steel, by the heading process, carbonized and hardened clear through and then highly polished. The balls are not truly spherical, nor of an exact size, but they are highly finished and very hard. The barrels may be of the single or multiple type, having one or more compartments. The barrel shown in Fig. 7 has two sections, and gives a general idea of the construction. The compartments are octagonal in shape and are lined with maple wood so that the balls and work do not come in contact with any metal during the burnishing process. Two hand-holes are provided for each compartment with covers which may be clamped in place. The two hand-holes furnish a means for quickly removing the contents and washing out the barrel. A lubricant is employed in burnishing, which ordinarily consists of soapy water.

To burnish a quantity of work, the work and balls are placed in the barrel in the proportion of one peck of work to two pecks of steel balls. Water is then added until it stands about one inch above the contents of the barrel. In this water, about four ounces of burnishing soap chips have pre-

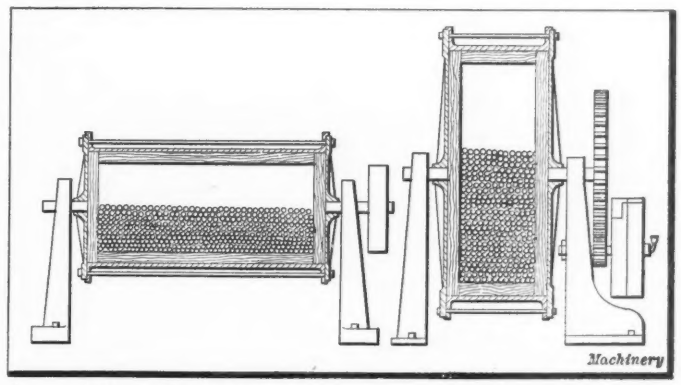


Fig. 4 Comparison of Old-style Barrel with Abbott Barrel

* Associate Editor of MACHINERY.

viously been dissolved. The hand-hole covers are then clamped in place, and the mixture tumbled from one to five hours, depending upon the character of the work, metal, etc. The speed ordinarily employed for tumbling ranges from 10 to 30 R. P. M., the usual speed being 15 R. P. M. If after tumbling, the work has a dull or smutty appearance, the soap solution should be drained from the work and clean water substituted, to which should be added a piece of cyanide of potassium about the size of a pea. It is highly important that the balls be kept from rusting, for rust, of course, destroys their burnishing qualities. The balls are easily kept in good condition by returning them to the barrel with the soap solution on them, but in no event should they be washed in clear water and allowed to stand. The burnishing operation is the same on all kinds of metal. After the work has been burnished sufficiently, it is separated from the balls by dumping the mixture into a screen of sufficiently coarse mesh to allow the balls to drop through. A convenient arrangement to use for separating the balls from the work is shown in the illustration Fig. 5.

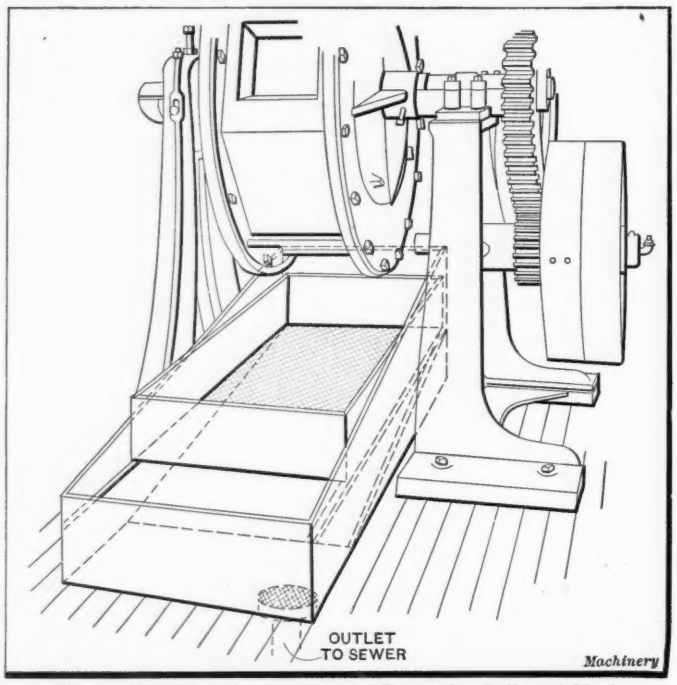


Fig. 5. Convenient Arrangement for Separating Balls and Work

If the work is not to be plated, it is taken from the barrel and dried in sawdust, but if to be plated, it is cleaned in the usual manner and plated. The cleaning operation incident to plating is usually very troublesome on account of the rouge that is driven into corners of the work by the polishing wheels. No such trouble is experienced after ball-burnishing, as no rouge is used. It is only necessary to rinse off the soap solution, dip in potash and plate. After plating, the work is returned to the barrel and tumbled in a soap solution for a half hour to impart a high finish.

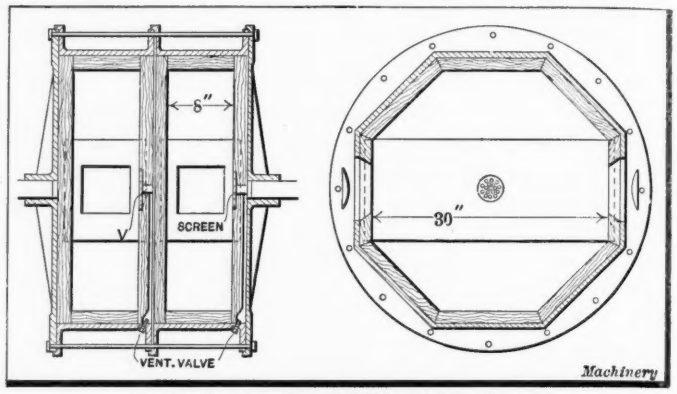


Fig. 7. Construction of Ball-burnishing Barrel

While most commonly used for small work, say under three inches in greatest dimension, larger work may be handled by a modification of the process. The difficulty in burnishing large work is due to the fact that the weight of the piece is often great enough to injure other pieces of work, and, of course, if the pieces are easily bent, there will be trouble from this source. Aside from the danger of bending large work in the burnishing barrel, a greater source of trouble is from scratches caused by the sharp edges of such pieces coming in contact with the finished faces of other pieces in the barrel. Referring to the illustration Fig. 8 a method of mounting pieces of this character is shown. Any convenient method of clamping is employed, depending, of course, on the shape of the pieces, but the fundamental idea is to support the pieces so that they cannot move in the barrel, and yet give the burnishing balls a chance to act upon the work exactly the same as though it was loose in the barrel. Mounted in this manner no possible injury can be done to the work and yet the balls have access to every part of the piece except the edge, even to the inside. It is apparent that this method cannot be used for all work, but a little ingenuity will often solve the problem without having to resort to hand polishing.

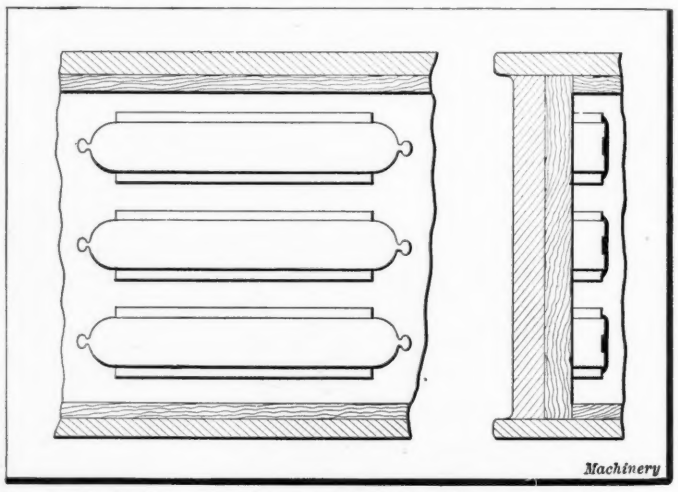


Fig. 8. Section of Barrel to show Method of Mounting Large Work

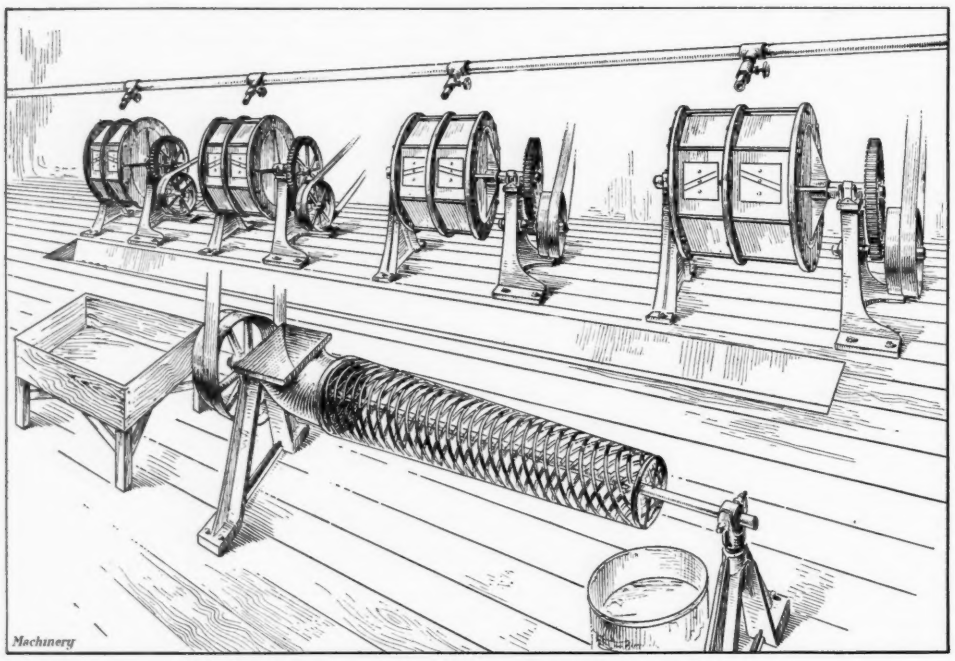


Fig. 6. Abbott Ball-burnishing Installation at Heron Mfg. Co.'s Plant

A typical installation of the Abbott ball burnishing process is found at the Heron Mfg. Co., Utica, N. Y. This installation

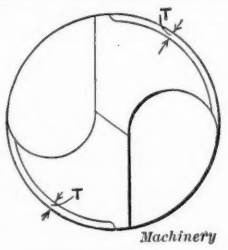
is represented by the illustration Fig. 6, in which are shown four double barrels driven from a common shaft. A line of piping extends over the four barrels, being connected with a hot water tank on the floor above. By means of outlets over the barrels, water may be admitted to the barrels for mixing the burnishing solutions, and for cleaning the barrels and their contents after the burnishing operation. A trolley system is arranged so that after the work has been dumped from a barrel into a basket, during which operation the suds and soap solution are carried away by means of the trough in front of the barrels, the work may be carried to the sawdust box for drying. This sawdust box is of the usual type and after the work has been sufficiently dried, it is shoveled into the chute shown at the right of the sawdust box, from which it enters the revolving conical screen cylinder and is separated from the sawdust, emerging from the small end of the screen, completely dried and ready for shipment.

By the use of this apparatus, the Heron Mfg. Co., who manufactures casters of all kinds, states that it is producing twice the number of parts at half the cost, and getting a better finish than when using hand polishers. Thus an expensive polishing and buffing equipment is eliminated, as well as the high priced labor formerly employed.

* * *

CLEARANCE ON TWIST DRILLS

In the June, 1911, number of MACHINERY an article was published entitled, "Data for Fluting and Relieving Twist Drills," which gave the dimensions of the fluting cutters used for grooving twist drills and also the thickness of the web and the width of the land (portion not relieved) on twist drills. The accompanying table gives the total amount of clearance, $2T$, for twist drills, as made by a prominent maker, the illustration showing how the dimension T is measured. The clearances given are for the finished drill sizes. Of course at the time the clearance is milled, the unrelieved portion of the drill is still a certain amount over the finished size. The amount of "oversize" must, of course, be added to the dimension T to determine the clearance in the unfinished drill. When measuring the depth of the clearance, the diameter is measured by micrometers over the relieved part. The dimension thus measured is the finished diameter of the drill less twice the dimension T. The thickness of the web as given in the June, 1911, number of MACHINERY is that at the point of the drill. Most makers groove their drills on a taper, which is so selected that the web is about forty per cent thicker at the upper end of the groove than at the point.



Machinery

AMOUNT OF CLEARANCE ON TWIST DRILLS

Size of Drill, No.	Total Clearance, 2 T	Size of Drill, Inches	Total Clearance, 2 T	Size of Drill, Inches	Total Clearance, 2 T	Size of Drill, Inches	Total Clearance, 2 T
80–68	No Clearance	15/64	0.016	1/2	0.033	1 1/16	0.059
67–60	0.003	1/4	0.017	17/32	0.035	1 1/8	0.061
59–56	0.0035	17/64	0.018	9/16	0.037	1 3/16	0.063
55–52	0.004	9/32	0.019	19/32	0.039	1 1/4	0.065
51–48	0.0045	19/64	0.020	5/8	0.041	1 5/16	0.066
47–44	0.0055	5/16	0.021	21/32	0 043	1 3/8	0.067
43–40	0.0065	21/64	0.022	11/16	0.045	1 7/16	0.068
39–36	0.007	11/32	0.023	23/32	0.047	1 1/2	0.069
35–32	0.008	23/64	0.024	3/4	0.049	1 9/16	0.070
31–28	0.009	3/8	0.025	25/32	0.050	1 5/8	0.071
27–24	0.0095	25/64	0.026	13/16	0.051	1 11/16	0.072
23–20	0.0105	13/32	0.027	27/32	0.052	1 3/4	0.073
19–16	0.0115	27/64	0.028	7/8	0.053	1 7/8	0.075
15–12	0.0125	7/16	0.029	29/32	0.054	2	0.075
11– 8	0.0135	29/64	0.030	15/16	0.055	2 1/2	0.075
7– 4	0.014	15/32	0.031	31/32	0.056	3	0.085
3– 1	0.015	31/64	0.032	1	0.057	3 1/2	0.085

The allowance made for grinding varies with different manufacturers from about 0.010 to 0.015 inch. When high-speed steel is used, 0.025 inch is allowed for grinding on account of the scale produced in hardening. Straight drills smaller than from about 3/8 inch to 1/2 inch are not ground after hardening, as they are made from drill rod of the correct size. On the larger sizes, however, there is considerable decarbonization of the outer shell, and it is advisable to make an allowance for grinding on all drills larger than 3/8 inch diameter, which, in fact, is the practice of many of the twist drill makers.

* * *

LIFE AND COST OF PATENTS

In an article in *Engineering* (London) of October 18, Mr. G. G. M. Hardingham gives a table stating the number of years during which patents are valid in various countries, and the total patent office fees paid for maintaining a patent during the specified number of years. It will be seen that in most countries the fees, which are given in the English money system the same as in the original table, are very much higher than those in the United States. It should be understood, however, that the large sums mentioned for some of the European countries are not payable in total at the time when the patent issues. In many countries yearly dues are payable in order to maintain a patent once issued. All these yearly dues have been added together so as to show the actual cost of a patent running for a specified term of years. Under the influence of the patent renewal fees in force in most European countries, a great many patents are annulled after they have been running only a few years, due to the fact that renewal fees are not being paid for them. In Great Britain, for example, statistics show that an average of 66.4 per cent of all the patents actually issued are annulled at the end of the fourth year, when renewal fees commence to become payable. Only 14.9 per cent of the total number of patents are renewed at the beginning of the eighth year; 7.6 per cent are renewed at the beginning of the eleventh year; and only 3.2 per cent run for the full term of fourteen years. It has been argued that patent renewal fees of some kind are desirable for the purpose of weeding out useless and unworked patents, but the correspondent of our contemporary, whose table is quoted, points out that there are two sides to this question. The table itself, however, is interesting as showing how cheaply a patent may be obtained and maintained for a period of seventeen years in the United States, as compared with the cost in the leading European countries. It also, probably, explains why the number of patents issued in the United States exceeds to such a large extent those issued in the other leading industrial countries.

TABLE SHOWING LENGTH OF TERM OF PATENTS AND TOTAL FEES IN VARIOUS COUNTRIES

Country	Term, Years	Total Patent Office Fees	Average Annual Cost of Entire Term of Patent
		£ s. d.	£ s. d.
Germany	15	257 10 0	17 3 4
Russia	15	228 7 0	15 4 6
Austria	15	164 12 0	10 19 6
Hungary	15	118 0 0	7 17 4
Holland	15	113 13 0	7 11 6
Denmark	15	111 15 0	7 9 0
Great Britain	14	100 0 0	7 2 10
Brazil	15	98 9 0	6 11 3
Belgium	20	84 0 0	4 4 0
Spain	20	84 0 0	4 4 0
France	15	60 0 0	4 0 0
Italy	15	60 0 0	4 0 0
Norway	15	58 2 0	3 17 6
Transvaal	14	53 10 0	3 16 5
British India	14	52 13 0	3 15 3
Switzerland	15	54 16 0	3 13 0
Sweden	15	40 18 0	2 14 6
Argentine Republic	15	38 2 0	2 10 10
Japan	15	27 13 0	1 17 0
New Zealand	14	18 0 0	1 5 8
Australian Commonwealth	14	13 0 0	0 18 7
Canada	18	12 7 0	0 13 9
United States of America	17	7 4 0	0 8 6
Mexico	20	4 2 0	0 4 1
Average	15.6	77 1 6	5 1 1

Machinery

LETTERS ON PRACTICAL SUBJECTS

We pay only for articles published exclusively in MACHINERY.

COMMENTS ON QUARTER-TURN BELTING ALIGNMENT

In reading Mr. M. H. Ball's article on quarter turn belting alignment in the September issue of MACHINERY, the writer is reminded of an incident which occurred some twenty-five years ago. A millwright was sent from a machine shop in central Massachusetts to install a water wheel and all of the power transmission equipment for a large mill in Maine. Included in the job there was a quarter-turn belt, 16 inches wide, that ran through five floors from the basement to the upper story. From the time he began the job, which was of some three months' duration, the quarter-turn belt was in the millwright's mind, as he had not the least idea how to install it. However, it was up to him to do it some way, and all his spare time was devoted to studying the matter. It may be said, in passing, that he had not a technical education, and therefore had no knowledge of descriptive geometry, but as the floors were all laid with hard pine tops, he did not want to cut belt holes big enough to let a wagon and oxen through. After studying the problem for some six weeks, the millwright went home for the express purpose of asking the boss how to lay out and cut the belt holes. The answer he received was, "If the pulleys were of the same size with only a single floor located midway between them, I could tell you; as it is, I don't know how." So the millwright returned to the job no more enlightened than when he left.

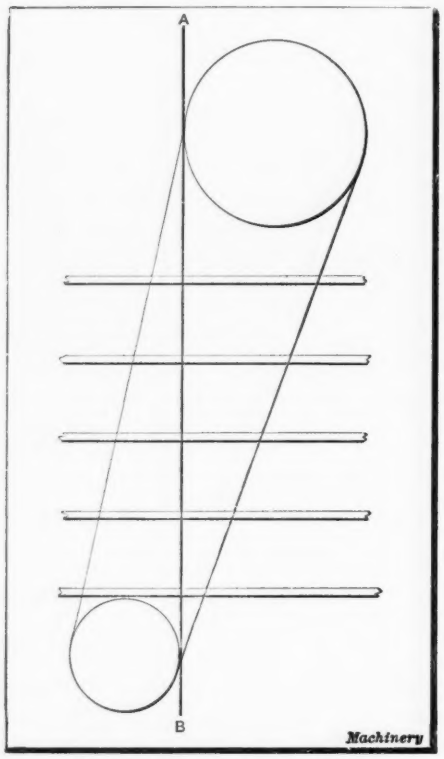


Diagram for laying out Belt Holes

One evening he took a compass and struck two circles to represent pulleys of different diameters, one above the other; he then drew lines representing an open belt from one pulley to the other, a line from the left of the upper pulley to the right side of the lower pulley, and lines to represent the five floors, as shown in the illustration. After studying over the sketch for some two hours or more the millwright was about to give it up for the night. He took up the paper and started to fold it on the line *AB*—purely mechanically—without any purpose whatever in doing so, but still thinking hard of the subject which had troubled him so long. He raised his hand to throw the paper into the fire, when it opened at an angle of about ninety degrees and caught his eye. He stopped and looked first at one side of the fold and then at the other, and was astonished as well as delighted to see that the solution of the whole problem was before him—perfectly plain and easy to understand. The line *AB* represented the plumb line through the floors, from the face of the upper to the face of the lower pulley, and the lines representing the belt showed the distances of the belt from the plumb line each way, and also the angle which the belt made in passing through the floors. The next morning the millwright made a drawing of the same thing to scale, and then to be absolutely sure, he made a model to the same scale, cutting all the belt holes, and putting on a model belt. He then laid out all the belt holes, allowing half an inch all around, and when the belt was put on it did not strike the side of any one of the holes. The writer believes that this incident shows what persistent thought and study will accomplish under most unfavorable circumstances.

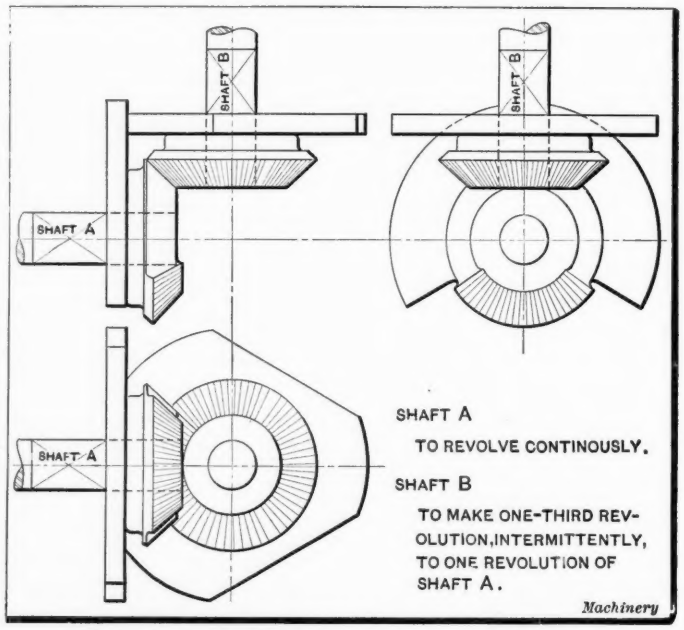
S. S. JENNISON

Cleveland, Ohio

AN INTERMITTENT MOTION

The feed rolls of machines for making cardboard fillers for egg boxes require an intermittent motion for their operation. They feed cardboard into the machine while in motion, and hold it for cutting while at rest. In one case a continuously running shaft was made to give this motion through an ordinary miter gear and a properly proportioned miter gear sector. This sector engaged and turned the miter gear during one-third of a revolution and then allowed it to remain idle during the remaining two-thirds. In the design of the machine no provision was made for keeping these ratios exact, further than by correctly proportioning the gears. As a consequence of slight variations, this combination gave much trouble through the gears not meshing correctly. This caused the gears to be broken, the timing of the feed to be destroyed, and the working of the machine to be generally deranged.

The illustration shows the method used for overcoming these defects and obtaining an accurate and sure-working feed



Mechanism for regulating Action of an Intermittent Motion

motion. It consists of a pair of flat plates attached to the shafts *A* and *B* behind the gears. The plate carried by shaft *B* is slabbed off on the three sides of an equilateral triangle, to give the correct dimension from center to edge, and the plate carried by shaft *A* is cut away to allow clearance for the plate on shaft *B* while turning. The mechanism acts exactly as before, except that when shaft *B* is idle, it is held in place by the bearing of one plate on the other. These plates limit the movement of shaft *B* to exactly one-third of a revolution for each revolution of shaft *A*. The former difficulties are thus remedied, and a smoothly running machine made possible.

MILES SAMPSON

Manchester, N. H.

ATTACHMENT FOR WINDING CLOSE COILS IN SPRINGS

The spring winding attachment shown in Fig. 1 is designed to fit on the back end of an ordinary lathe headstock. The attachment can be set to produce from one to two and one-half

close coils, at required intervals, so that a spring of the full length of the lathe can be wound and then cut up into lengths. This method of close coiling makes it possible to save the time that was formerly taken in closing the ends by hand or in heating the ends of larger springs before closing them up.

The attachment is driven by the screw cutting stud, through the regular change-gears, to the lead-screw, as in an ordinary screw cutting operation. The nut is kept in engagement with the screw all the time. The change-gear is loose on the screw cutting stud, but has a clutch member keyed to it; the other part of the clutch is keyed on the stud and has a spring to push it into engagement. When these two clutch members are in engagement the apron travels forward; when the clutch

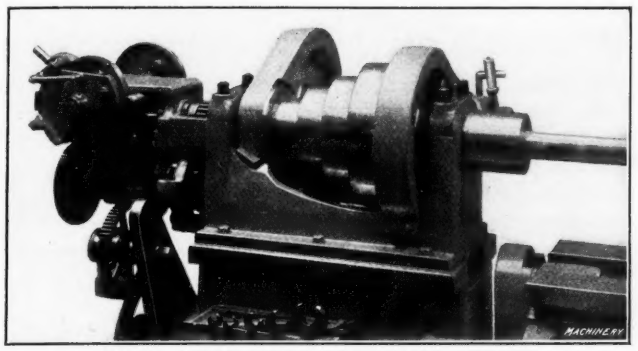


Fig. 1. A Lathe Attachment for winding Springs

is disengaged the apron stands still but the spindle continues to revolve.

The screw cutting stud is continued outward and drives a cam *A* by means of two gears, as shown in Fig. 2. This cam runs continuously and acts on a runner attached to the curved lever *B* which carries a spring plunger or pawl *C*. Each time the lever reaches the top of its stroke, the pawl carried by it acts on the ratchet wheel and picks one tooth. The ratio of the gearing which actuates the cam is such that it requires three strokes of the lever for each two coils of spring which are wound. The ratchet wheel is prevented from coming back by means of the fixed catch *D* at the top, which holds it against the weight and rope tending to pull it back. On the side face of the ratchet wheel there is a T-groove in which a dog is clamped. As soon as the ratchet wheel has been advanced through the required distance, this dog comes against a projection *E* on the inside of the ratchet mask; the ratchet and mask then travel together. The mask has a gap through which the pawl usually works; consequently it remains stationary until it is engaged by the dog on the ratchet wheel. This mask is rather larger than the ratchet wheel, the bottom of its teeth being slightly above the top of those on the ratchet, so that when it begins to move, the pawl *C* and fixed catch *D* are both lifted out of contact with the wheel and allow it to go back under the pull of the rope and weight.

Shortly after the mask begins to move, its corner comes in contact with the cam runner on the lever which controls the stud clutch. This throws out the clutch and stops the travel of the apron. The mask continues to rotate through the action of the pawl until it has produced the required number of close coils. An adjustable dog for lifting the catch now comes into action and throws the catch out of engagement with the mask; the tension of a spring then returns the mask to its original position. This releases the clutch lever and allows the drive on the screw cutting stud to be reengaged. At this point, the apron continues its forward movement for the production of another section of the spring. When the mask is returned, the fixed dog, which it carries, pushes the retaining catch into engagement with the ratchet wheel, thus restarting the latter in rotation.

Means are provided to cushion the weight so that the full shock does not come on the attachment. Suitable means have been taken to adjust the ratchet pawl so that it takes only one tooth at a time, also to have it drop clear of the ratchet wheel in order that the latter may be given time to run back when the action of the weight becomes effective. The design of the teeth of the clutch on the screw cutting stud must be such that they will have plenty of clearance and not too strong a spring behind them, as this would make the return uncertain.

The pitch of the spring is obtained in exactly the same way as the pitch of a screw produced in the ordinary manner. The attachment merely determines the length of each section of the spring and the number of close coils that are to be produced.

Keighley, England W. HAGGAS

CASEHARDENING PRACTICE—A COMMENT

The writer would like to make a few friendly criticisms and comments on Mr. Robert Grant's article on "Casehardening and Casehardening Practice" in the October number of

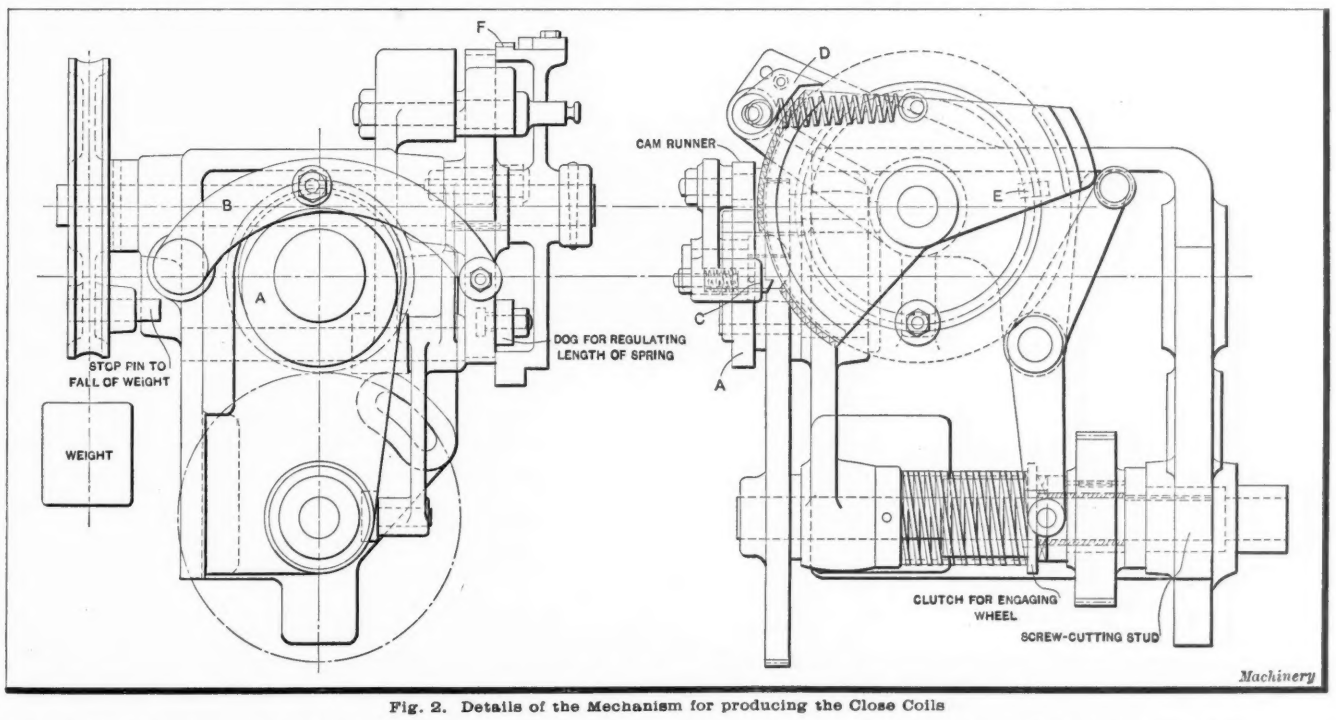


Fig. 2. Details of the Mechanism for producing the Close Coils

MACHINERY. In the first place, the general methods outlined are not entirely in accordance with the most modern practice. However, the article is good and in most cases it treats of the present methods practiced all over the country.

The statement is made that carburized steel should never be quenched at the carburizing heat, but should be cooled to the hardening heat, as the latter is much lower than the carburizing heat. This would make little improvement, for the grain of the steel would be about the same as if it had been quenched at the highest temperature attained while

carburizing. It is necessary to cool the steel below its lowest critical point (about 1275 degrees F.) and then reheat it to the hardening temperature, thus quenching on a rising heat, in order to secure a refined grain. Steel should never be quenched on a falling heat.

Mr. Grant's method of local hardening is not the most modern, and it is expensive and troublesome. He shows a cup-shaped piece in Fig. 6, which was only hardened at the interior of the cup, using another cup-shaped piece to prevent the outside from hardening. There is now a prepared fire paint on the market which works admirably when painted on parts of steel that are not to be hardened. This paint is in the form of a powder and is mixed up with water to the consistency of paste; it is then ready to be applied. The steel can be painted before or after carburizing. If painted before, the part of the steel which it covers will not be carburized, and consequently it will not harden. If the paint is applied after carburizing, the painted steel will not harden, although it is carburized, because the paint forms a shield which does not let the water come in contact with the steel. This makes local hardening a simple proposition, and is superior to copper coating. The use of the mandrels shown in Fig. 5, for preventing the hardening of the inside of rings, could be done away with by using this fire paint. The fire paint is also useful in corners where a thin part joins a thick part in the steel, the paint forming a fillet that leaves the corner soft after hardening and prevents breakage.

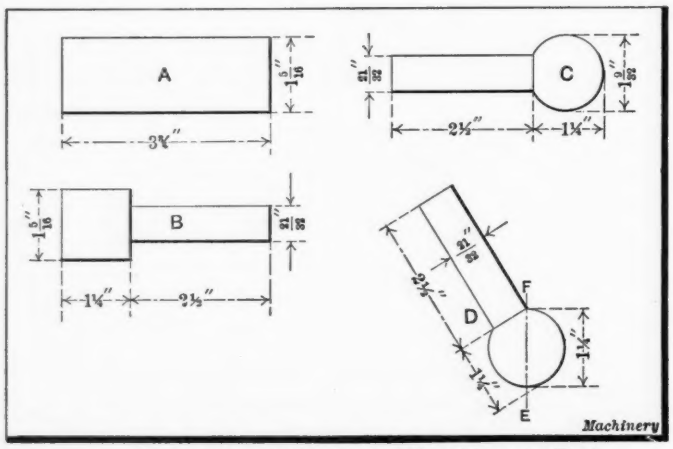
Mr. Grant says that small pieces packed in a box for carburizing may touch each other without detriment. It is hardly possible that this would be true in actual practice, because the surfaces in contact would prevent direct contact of the carburizing material; therefore these spots would get little or no carbon, and the steel would either have soft spots after quenching or the depth of case would be irregular.

The method of drawing the temper of hardened steel by heating it in a muffle is not nearly so reliable as drawing it in oil, where the temperature can be accurately gaged with a thermometer. Drawing in oil is a more rapid and accurate method. Mr. Grant says that large articles require a higher carburizing heat than small ones. The writer does not see the reason for this. Of course it takes a higher heat to penetrate a large piece in the same time as a small one, but it seems that if two pieces of steel—one small and one large—are held at the same uniform heat for the same interval of time, they will each receive the same depth of case.

Cleveland, Ohio J. E. WASHBURN

TURNING SPHERICAL SHAPES BY HAND

Special fixtures and methods for ball turning have been shown and described in recent issues of MACHINERY. The accompanying illustration shows a method which the writer



Successive Operations in Turning Ball-shaped Parts by Hand

recently used in a job shop where no ball turning device or lathe with a compound rest was at hand. The pieces to be turned up are stub ends to be welded onto the steering arms of automobiles for repairs. After cutting off the pieces, as shown at *A*, they were faced to the proper length and centered, and were then caught in a three-jaw universal chuck and one end was turned down, as shown at *B*. The pieces were then reversed in the chuck and the ball shape was roughed out by hand as accurately as practicable, as indicated at *C*. They were then caught in the chuck in the position shown at *D*, on the points of the chuck jaws, so that a circle could be turned to 1¼ inch diameter along line *EF*. Preferably, this should be done in an independent jaw chuck so that the circle turned in this position will agree as nearly as possible with the diameter marked 1 9/32 inch, previously turned. The pieces are then returned to the position shown at *C*, and the ball is finished, the circle turned to 1¼ inch diameter being used as a "witness" mark. H. W. RICKS

Santa Ana, Cal.

TURNING A BALL WITHOUT CENTERS

It was required to turn the brass ball shown in Fig. 2 without the use of centers, and in performing this operation the following method was used. A 4-inch bar was chucked in the lathe and the ball roughed out. The compound rest was next set with the pivot directly beneath the center of the ball and slowly swung around to form the work. The tool was fed in until the caliper showed that the ball had been reduced to

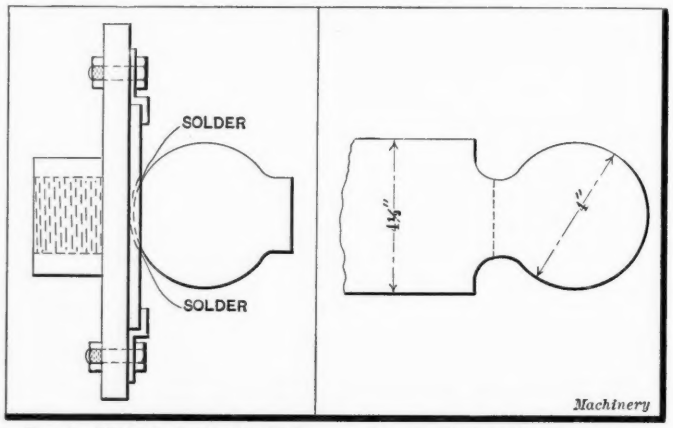


Fig. 1. Method of securing Ball to Faceplate

Fig. 2. Ball ready to be cut from Bar

the required diameter of 4 inches. This turning operation was continued until the work had been brought to the form shown in Fig. 2. The ball was then cut off along the dotted line leaving sufficient stock to finish.

The chuck was next removed and a faceplate mounted on the lathe spindle in its place. A brass plate was then strapped to the faceplate and a hollow was turned in it with the tool in the compound rest. The same radius was used for this purpose and, consequently, the hollow formed was of exactly the right size to hold the ball. The work was then mounted in the position shown in Fig. 1 and the tailstock brought up against it to secure it in place. Soft solder was now melted into the joint between the ball and disk, a blow torch being used for this purpose. This method of fastening proved entirely adequate to hold the work in place after the tailstock had been removed. The remaining surface of the ball was then finished. In performing this operation, it was necessary to maintain exactly the same radius on the compound rest, but this did not interfere with the possibility of moving the rest along the lathe bed to bring it into position for completing the ball.

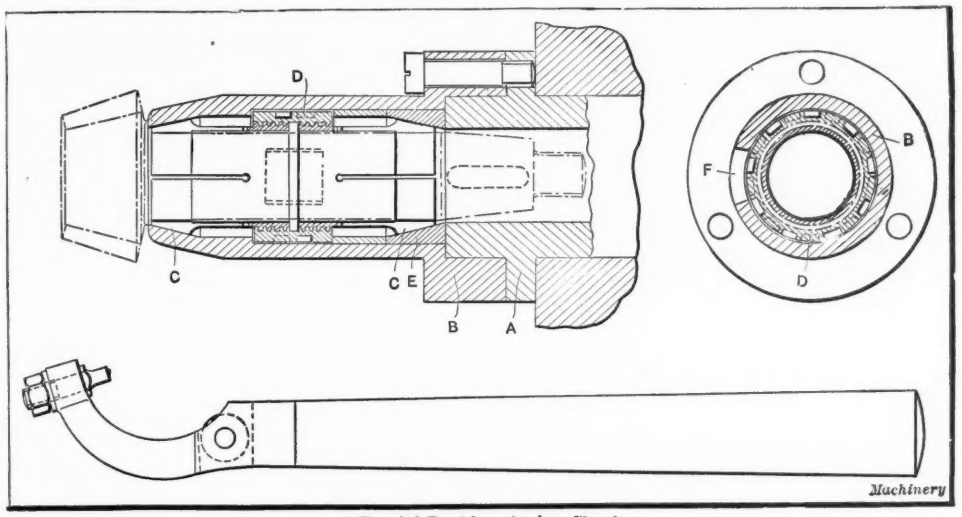
The advisability of turning balls in this way may be questioned, as some may regard the method of turning them between centers and then grinding off a more rapid process. This is true in some cases, but for the operation described in this article it was necessary to have the ball accurate to 0.0001 inch, and the method described enabled the work to be produced to meet this requirement.

New Britain, Conn. J. M. HENRY

DOUBLE GRIPPING CHUCK

In the shops where the writer is employed we had to rough out some very hard nickel steel miter gears on a spur and bevel gear cutting machine. The usual chucking devices at our disposal failed to do their duty, as we could not possibly take the heavy cuts without moving the work.

The double gripping chuck shown in the accompanying engraving was, therefore, designed and proved quite effective. At *A* is shown the machine spindle; *B* is the chuck which is firmly fastened to the spindle by means of three screws. At *C* are shown two conical split collets which are fitted on the inside of the chuck, the front one resting in a taper seat, while the rear one rests in a ring *E* held against the front of the machine spindle. Both collets are threaded on the outside with a right- and left-hand thread, respectively, and are screwed into a ring *D* which holds them together. The ring has, on the outside surface, spanner holes so arranged in two rows around the circumference, that when the ring is rotated they alternately pass in front of a rectangular opening *F*.



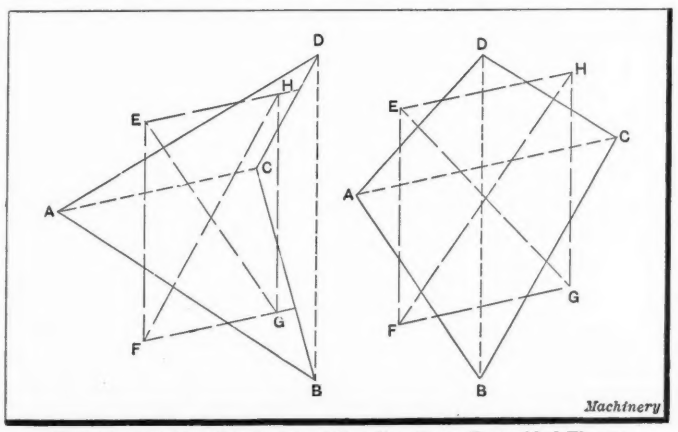
A Special Double-gripping Chuck

Through this opening the tooth of the spanner shown in the lower part of the engraving is inserted. Ring *D* is thus rotated, and the two collets *C* operated against the taper surfaces, so as to clamp the work firmly in position.

Turin, Italy. G. BOELLA

FINDING THE CENTER OF GRAVITY OF ANY FOUR-SIDED FIGURE

In many calculations pertaining to the design of machinery, it is necessary to find the center of gravity of irregular polygons, and the following is a simple method of obtaining the center of gravity of any four-sided figure. Two cases are possible, as shown in the illustration. To find the center of gravity of the four-sided figure *ABCD*, each of the sides is



Method of finding the Center of Gravity of any Four-sided Figure

divided into three equal parts. A line is then drawn through each pair of division points next to the points of intersection *ABCD* of the sides of the figure. These lines form a parallelogram *EFGH;* the intersection of the diagonals *EG* and *FH* locates the required center of gravity.

McKees Rocks, Pa. AUGUST H. ANGER

[To prove that *EFGH* is a parallelogram, a line is drawn connecting points *B* and *D*. This forms two triangles *BCD* and *BAD* having the common base *BD*. It can be shown that a line which subdivides any two sides of a triangle proportionately is parallel to the third side. The line *EF* divides the sides *BA* and *DA* in the ratio of 2 to 1, and so it is parallel with *BD*. The line *GH* divides sides *BC* and *DC* in the ratio of 2 to 1, and so it is parallel with *BD*. Hence the lines *GH* and *EF* are parallel to the common line *BD* and with one another. To prove the sides *EH* and *FG* parallel with one another, a line is drawn connecting points *A* and *C*. The same method will then show that the lines *EH* and *FG* are parallel to the common base line *AC* and, consequently, to one another. Hence *EFGH* is a parallelogram.—EDITOR.]

ERASING INK MARKS FROM TRACINGS

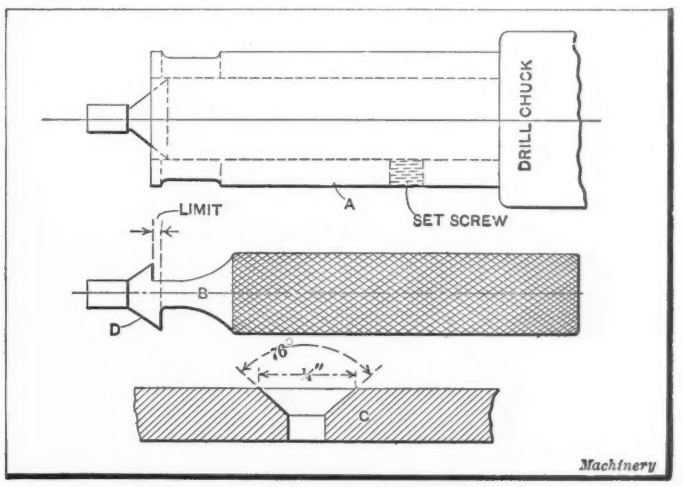
The writer, a draftsman of twelve years experience, has read many articles on the well worn subject of "Erasing Ink Marks from Tracings," but has seen nothing that agrees entirely with what he has found to be the most satisfactory method. To begin with, an ink line is one of considerable breadth and thickness. When an eraser is applied it grinds the ink up into minute particles, which are worked into the cloth as soon as the glaze is broken; these particles of ink are only removed by much unnecessary rubbing. The following is a more satisfactory method:

Place a triangle or other hard, smooth surface beneath the line or spot that is to be erased from the tracing cloth; then with a very sharp knife remove the ink which lies on top of the cloth. This means the ink which has not actually sunk into the cloth; do not scratch into the cloth. If sufficient care is exercised, the knife need scarcely break the glaze. Then, still keeping the triangle under the tracing and using a hard pencil eraser—do not use an ink eraser—it will be found that the remainder of the ink can be completely removed with little injury to the cloth. By this method, the troublesome grit coming from an ink eraser is avoided, and by applying a small amount of soapstone, the surface of the cloth is renewed sufficiently to prevent the pores filling up with dust and becoming unsightly. As a general thing, a knife is tabooed as an eraser, and with good reason, but when used according to the method outlined, the writer has found it far superior to an ink eraser.

Auburn, N. Y. RAYMOND H. FARWELL

STOP-SLEEVE AND GAGE FOR COUNTERSINKING

The writer has had considerable difficulty in accurately countersinking holes in thin sheet metal; hence, a gage or stop-sleeve was finally devised which answered the purpose



Stop-sleeve and Gage for Countersunk Holes

so well that a description of it may be of interest to others who may have met with trouble of the same kind. The countersinking of holes in sheet metal to a uniform depth com-

bines the difficulties of ordinary countersinking with the additional difficulty that the sheet metal is apt to spring away somewhat from the tool. Trouble is also met with on account of slight bends in the sheet.

The stop shown at *A* in the accompanying illustration is a sleeve which is placed over the countersink. The top of the sleeve fits against the face of the drill chuck and is prevented from falling off the tool by a set-screw. Openings near the bottom provide an outlet for the chips. The bottom face of the sleeve is hardened and slightly drawn. It is then polished as smoothly as possible with fine emery so that it will not mark the stock. When the countersink has reached the proper depth, the face of the stop will revolve on the stock and thus prevent the tool from entering further. The pressure on the sleeve will tend to straighten out any bends in the sheet metal and make certain that every hole will be countersunk to a uniform depth.

A test gage for countersunk holes which may be of interest is shown at *B*. It is provided with a pilot for entering the drilled hole. One side of the gage proper is ground away, as indicated, to a level lower than that of the other side. In this way, the allowable limit of variation in depth of the countersunk hole is given on the gage in a very convenient way. The part *D* is ground and by using Prussian blue or red lead in gaging, the angle of the countersunk hole can be easily tested.

Many draftsmen when dimensioning a countersunk hole give its depth. This is not a convenient dimension for the shop men to work from, as it is practically impossible to measure the depth accurately without a gage; hence, countersunk holes should be dimensioned as shown at *C*, the diameter at the top and the angle being given. F. A. PARSONS

Milwaukee, Wis.

JIG FOR DRILLING HOLES CLOSE TO A SHOULDER IN SCREWS

A jig for drilling holes close to a shoulder in a screw is shown in Fig. 2. The hole to be drilled is for the threading tool to run into, when cutting threads up to the shoulder on

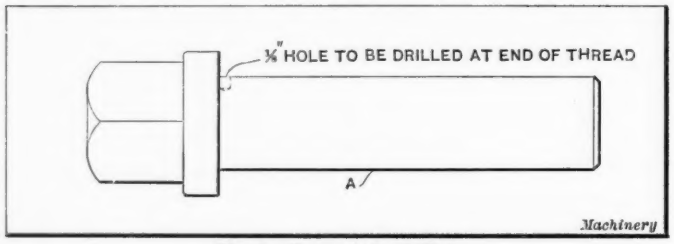


Fig. 1. Screw to be drilled

the screw shown in Fig. 1. The jig is placed in the tailstock of a lathe, and the drill is held in a chuck in the headstock.

In operation, the body *A* of the screw, Fig. 1, is held with the left hand in the V-part of the jig, with the shoulder against the

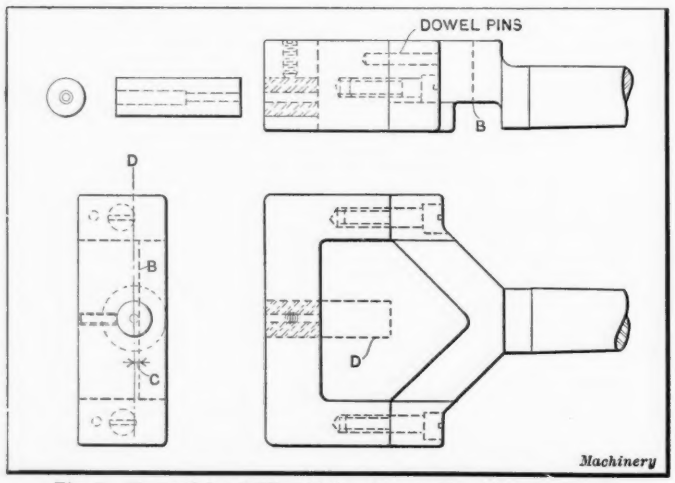


Fig. 2. Jig used for drilling Holes close to Shoulders in Screws

cut-away portion *B* (the face *B* is equal to the radius of the drill or the distance *C* from the center), while the right hand is used to run the tailstock spindle out, or, in other words, to feed the work against the drill.

In this jig the work is quickly done with a sufficient degree of accuracy, and if the drill used is ⅛ inch in diameter, screws of ⅛ inch pitch or less and of various diameters can be drilled, which makes this a handy jig for drilling odd half-dozen lots, as well as a greater number of pieces.

The long bushing *D*, shown in Fig. 2, is for supporting the drill on small diameters, as it projects further through the cap, as shown by the dotted lines. M. F.

A SWAGING OPERATION

In swaging the piece *A* to the shape *B*, Fig. 1, and in other similar work, trouble is often experienced in obtaining a satisfactory means of locating the work, owing to the flash which spreads entirely around the piece. In Fig. 2 is shown

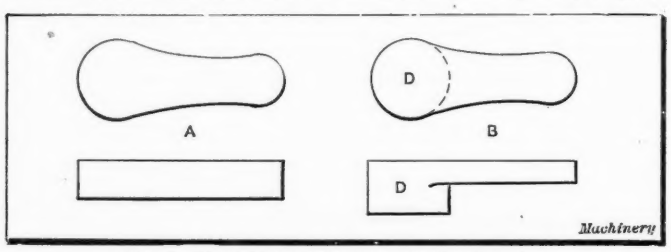


Fig. 1. Piece of Work before and after Swaging

a punch and die for swaging this part. The work is located between the spring-operated holders *A* and directly over the die, which has a hole *B*, 3/32 inch deep, in it. The small end of ejector pin *C* forms the bottom of the hole in the die. When the piece is swaged into the die, this pin compresses

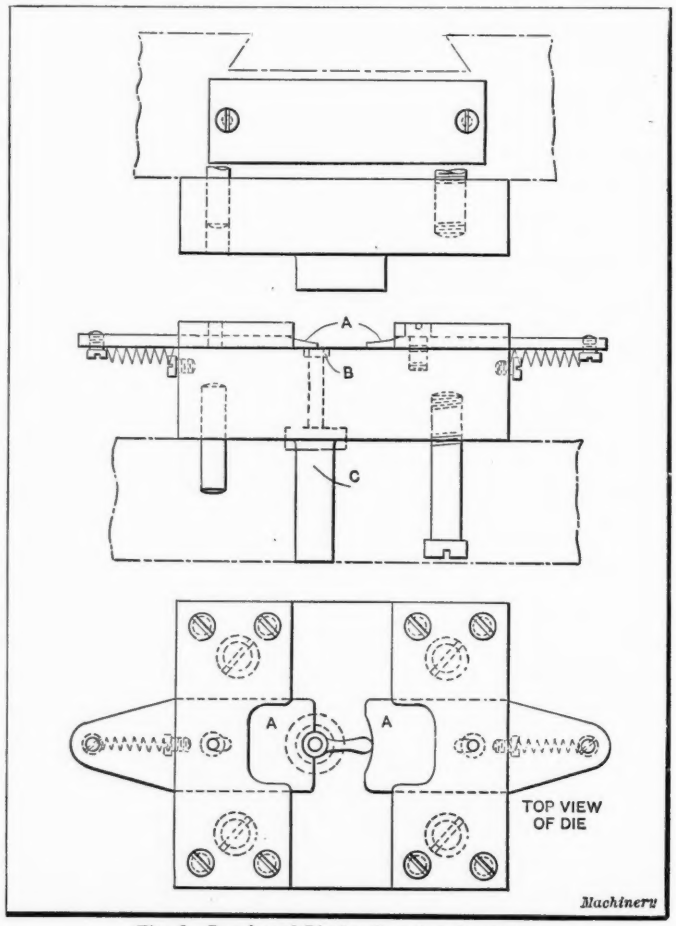


Fig. 2. Punch and Die for Swaging Operation

the rubber pad which is used for ejecting. A small ring is formed on the work by the hole through which this ejector slides; this is afterwards removed by a drilling and reaming operation through boss *D*, Fig. 1. BACON

MACHINING AN AUTOMOBILE SPIDER

The piece shown at *B* in Fig. 1 is known as an automobile spider. It has four arms which are finished on the outside, and a hole bored through the center. The machining operations on the spider are carried out as follows: In the first operation the spider is gripped in a three-jaw chuck, as shown in Fig. 1, one jaw being cut out to allow one of the arms of

the spider to set into it, thus furnishing a drive. While the hole through the spider is being bored and reamed with tools held in the turret, one side of the spider is faced with a back facer bar which is operated through the spindle, and the side next to the turret is faced with tools held on the cross-slide. In this operation the ends of the arms of the spider at *A* are also turned.

Before the second operation on this spider is done it is necessary to drill a small hole *A*, Fig. 2, which is used to locate the spider on the turret for the second operation. This hole is drilled in a jig as shown, which consists of a base on which the spider is set and an upper half which locates the

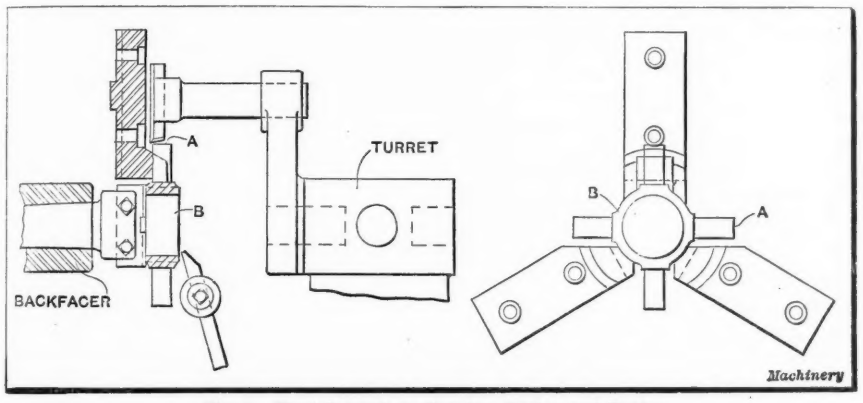


Fig. 1. First Operation—Turning, Boring and Facing

hole. Fig. 3 illustrates the method of machining the arms in the second operation, this being quite a departure from ordinary turret lathe practice, in that the tools are held in the headstock spindle, and the work on the turret. In place of the regular turret a special turret is used for holding the spiders, each spider being located in the same position as the preceding one by means of the hole mentioned above and the pin *A*, Fig. 3.

It is obvious that if there are four turret faces on the regular turret, the same will be true of the special turret, and each indexing of the turret brings another arm in line with the spindle, where it is operated upon. When the four arms are finished the machine is stopped and another spider put

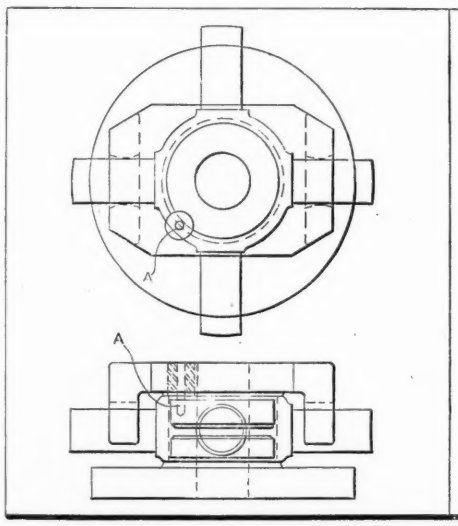


Fig. 2. Jig for Drilling Locating Hole

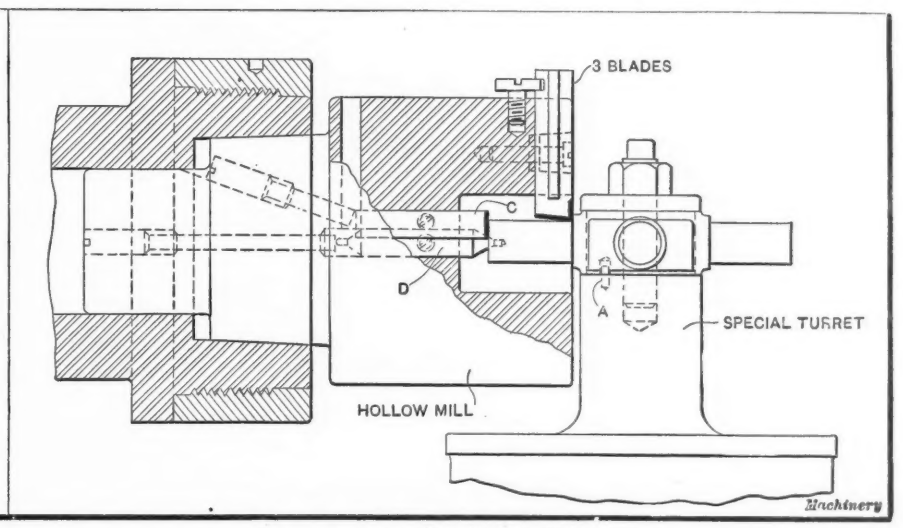


Fig. 3. Turning and Facing the Spider Arms

on. The machining on the arms of the spider is done with a hollow mill held in the spindle. In this mill there are three blades for turning, one facing blade *C*, which faces the end of the arms, and a small combination center-drill *D* which centers each arm. As the arms on the spider are opposite, they can be set between centers and ground, a pin being used to drive them by simply coming in contact with one of the arms not being ground; this saves the necessity of using a dog and is much quicker. F. SERVER

A COMPARISON OF SELLING METHODS

Some time ago we were in the market for a machine tool and wrote to two manufacturers who advertise in these columns. The selling methods of these two companies differed sufficiently to cause comment. Our letter asked for information regarding prices, the type of equipment that would be best suited to our requirements and the correct method of installation. The replies came promptly but the difference can be noted from the following: Firm No. 1 enclosed a blueprint photo of machine and a printed pamphlet of general information on the method of installation, etc. Their letter made no mention of the special information we asked for and appeared to be a stereotyped form. Nor was this information included in the pamphlet, and to complete a poor argument, the letter was signed in typewritten characters, no writer's name appearing. Firm No. 2 sent an attractive catalogue with prices—which, by the way, were higher than those submitted by firm No. 1—and a three page letter *fully* answering all of our requests, and calling attention to a few salient points not mentioned in the catalogue. They advised that their salesman would reach us within three days to enter into the matter still more fully. In conclusion, the letter was personally signed by the head of the firm, thus giving that touch of individuality which means so much. The salesman arrived on time, explained some minor points—the letter had covered nearly everything—closed the order, and the machine was shipped in three weeks. Although we would have paid for it on delivery, the builder insisted that we take up the thirty day trial offer, which was done. Needless to say, the machine is still in use and further purchases are now contemplated.

The reason for asking the special question concerning installation and equipment was that remodeling was necessary to accommodate the machine. It was necessary to start this work at once, in order to be ready when the machine arrived; consequently it was a matter of absolute necessity for us to have these questions answered. We notified firm No. 1 that the order had been placed, but received a stereotyped "follow up letter"—signed in typewritten characters as before. While merits, of course, were the final considerations governing our selection, the first impressions made by the letters went a long way in making the decision. It does seem as though some firms should adopt twentieth-century methods of selling their goods. One thing more; these firms were located in the same town and manufactured the same line of machines, so that both had equal opportunities of securing the business.

New Britain, Conn. J. M. HENRY

PUBLISHING TECHNICAL INFORMATION

In the September issue of MACHINERY, appeared an editorial comment on an article recently published in *Canadian Machinery*. The article in question spoke of the selfishness of some engineers who refrained from giving out useful technical

information which was the result of personal research. Modern methods and ways of thinking are making this type of men a thing of the past.

There are, of course, various reasons for this policy, one of which was brought out by an experience which the writer recently had. The superintendent of a certain factory, having noted one of the writer's articles on a method of performing an important operation, came to him and said, "I don't believe in this sort of thing and the president also expresses himself as being against it." Upon being asked for the reason he replied, "Simply because we do not believe in the general education of the masses." The writer refrained from making any comment, but to him it surely seems a narrow-minded view. The article did not reveal any trade secrets or information of that nature, being merely a description of a short cut in machine production.

Some people appreciate the publicity which comes from advertising, etc., but fail to appreciate the publicity value of giving out their methods of manufacture to the trade. Competition makes it necessary for every short cut to be applied, but does not, in the writer's opinion, require withholding information that would be helpful to a great many mechanics. This only refers to information that could be made public without loss to the works where the method originated.

It will generally be observed that the shops which guard their fancied secrets so jealously are the ones in which time, money and energy are wasted most freely. The reason for this is that their narrow-mindedness prevents them from accepting other known and tried methods of improving their working conditions. Perhaps they are ashamed of their methods. If this narrow view were broadened, it would clear away much of the mystery which surrounds the intelligent use of modern machine tools and appliances, and the benefits received would fully repay manufacturers for giving out information which is at their disposal. J. M. H.

DRAWINGS AND THE EYE-SIGHT

There is altogether too much unnecessary eye-strain among draftsmen that is weakening their sight. This is not brought on entirely by the continuous use of the eyes; other causes of eye-strain are making and reading drawings with lines of inadequate thickness, using lead pencils that are too hard, and making tracings from pencilings whose lines are barely distinguishable through the cloth.

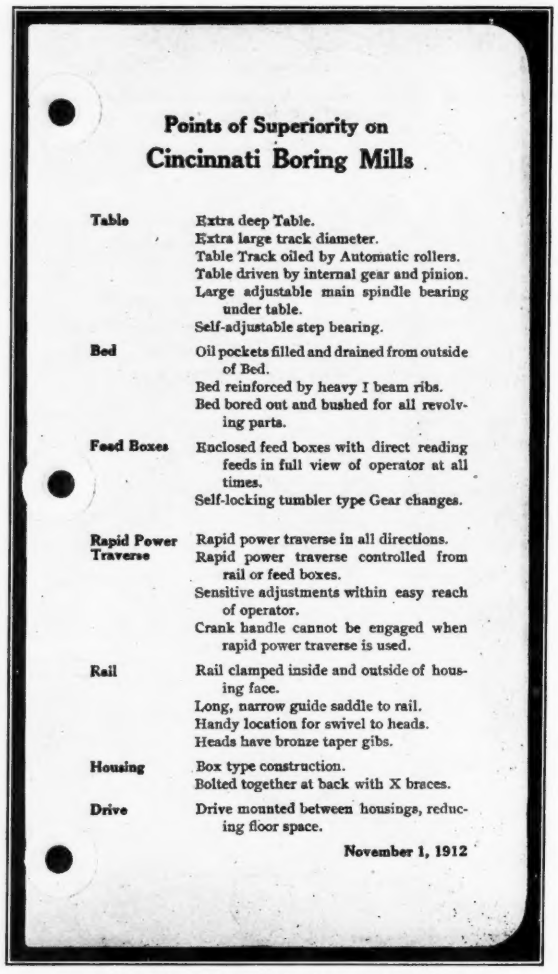
The exercise of a little discretion in selecting drawing materials and in drafting-room practice may be made the means of saving both the draftsmen and those who use their drawings from eye-strain. It is more difficult to trace a penciled drawing made on buff or cream colored paper than one made on white paper. Many draftsmen use but one degree of hardness in lead pencils—generally a 5–H or 6–H on all shades and grades of drawing paper. They do not appear to realize that there is a proper degree of hardness of lead for different papers, that will make a drawing "seeable" and "readable" through tracing cloth in all conditions of light, whether the day is stormy or bright. In most drafting-rooms, the papers used have a coarse-grained surface and are either white, buff or cream colored. Experience has shown that on white drawing paper, a 5–H pencil makes lines of sufficient weight, on the buff color a 4-H should be used, and on the deeper shades a 3–H is desirable. Since a much greater pressure can be secured in making lines with a lead pencil than with a pencil compass, the lead in the compass should always be one degree softer than the pencil. If this method is followed, all drawings will have good black lines, which will lessen the strain on the eyes, especially when making tracings.

Another means of relieving eye-strain is to make the light and shade lines thicker. The day of elaborate drawings for shop use has passed. Plainness and simplicity in drawings is both required and appreciated by workmen. It is better to use a drawing pencil having too blunt a point and make thick lines, than to use one filed down to a point like a needle. In making tracings, plenty of ink should be used. The lines that were formerly made for shade lines should now be the light lines, and the shade lines should be made just double the thickness. The lettering and figures on the drawing should be made with a coarse pen, and at least 5/16 inch high and 3/16 inch wide. Blueprints taken from such tracings are far more useful in the shop than many of the ones with sight destroying hair-lines, dwarfed letters and figures, and feeble looking arrow-heads that are now in use. All this may seem a radical change from the present method, but its general adoption would be a change in the right direction, as it would enable those with dimmed eyesight to read drawings more easily and prevent damage to the sight of those whose eyes are still good. JAMES E. COOLEY

Hartford, Conn.

PRICE SHEETS FOR SALESMEN

On page 235 of the November issue, engineering edition, attention is called to the loose-leaf price books that are now generally used by machinery salesmen. We have been sending out our price lists in this form for the past six years, the size of the sheet being 7¼ by 4 inches, suitable for the Morden No. 6 loose-leaf binder. All information which we issue for



Points of Superiority on
Cincinnati Boring Mills

Table	Extra deep Table. Extra large track diameter. Table Track oiled by Automatic rollers. Table driven by internal gear and pinion. Large adjustable main spindle bearing under table. Self-adjustable step bearing.
Bed	Oil pockets filled and drained from outside of Bed. Bed reinforced by heavy I beam ribs. Bed bored out and bushed for all revolving parts.
Feed Boxes	Enclosed feed boxes with direct reading feeds in full view of operator at all times. Self-locking tumbler type Gear changes.
Rapid Power Traverse	Rapid power traverse in all directions. Rapid power traverse controlled from rail or feed boxes. Sensitive adjustments within easy reach of operator. Crank handle cannot be engaged when rapid power traverse is used.
Rail	Rail clamped inside and outside of housing face. Long, narrow guide saddle to rail. Handy location for swivel to heads. Heads have bronze taper gibs.
Housing	Box type construction. Bolted together at back with X braces.
Drive	Drive mounted between housings, reducing floor space.

November 1, 1912

Morden Price List Sheet with Reinforced Holes

the use of salesmen, such as dimensions, talking points, motor information, etc., is printed on sheets of this size, and we have just adopted a scheme of reinforcing the holes as shown by the sample sheets enclosed. These price lists are referred to constantly by the salesmen, and unless some provision of this kind is made, the holes are soon torn through and new sheets must be supplied.

Cincinnati, Ohio CINCINNATI PLANER CO.

REFITTING A WORN STRAP ON AN ENGINE CONNECTING-ROD

The writer read with considerable interest an account in the August number of MACHINERY of how a number of rings that had been bored out too large were saved by shrinking and reboring them. This recalled to his mind a job of a somewhat similar nature which he saw done while an apprentice. A large engine was being repaired and generally overhauled. The strap for the connecting-rod required re-

fitting, but instead of making an entirely new strap, the old one was heated to a red heat across the end and immersed in cold water for about one-half the thickness of the stock; thus the outside portion contracted and compressed the inner portion in a manner similar to that explained in the article referred to. This method might be used to advantage in many cases, if it were better known.

Los Angeles, Cal. JOHN A. WOOD

EFFICIENCY OF WORM GEARING

We have read with much interest the article published in the September issue of MACHINERY entitled "Efficiency of Worm Gearing for Automobile Transmission." We have made a large number of tests on worm gearing in these works and our results do not confirm the results given in the article in question. We should be glad, therefore, to have certain points explained. The general trend of the tests given in Tables I to V shows that the efficiency decreases with decreasing load, which is entirely opposite to our results.

It appears to us that the loss in friction is proportional to the working pressure between the teeth, and, therefore, when the working pressure is less, the loss in friction is less. However, in Table III, "Second Speed" test, the loss at 36.95 H. P. is 0.84 H. P., and at 19.12 H. P., 1.14 H. P.; also, in the same table on the "Direct Speed" the loss at 49.35 H. P. is 1.21 H. P., and at 30.73 H. P., 1.89 H. P. We cannot see how these figures—and there are several similar cases in the other tables—can be substantiated.

We also note that later in the article appears the following remark: "The higher loads indicated were abnormal for the gears under consideration, and would not occur in any use to which the gears would normally be put." A consideration of the tables shows that as the highest efficiencies are always obtained at these abnormal loads the gear should surely be taken to be correctly rated for these loads, and a *smaller* and (according to these results) *more efficient* gear should be designed for the *normal* working load required. It also appears from the tables that if the load were still further increased, an efficiency of 100 per cent might readily be obtained.

In conclusion, we may say that our experience gives the following general results, *viz:* that the efficiency of a correctly designed gear increases considerably under light load and decreases under overload, and that the temperature rise of the oil is an exact measure of power loss in the gear.

Manchester, England. HENRY WALLWORK & CO., LTD.

I have read with much interest the comments made by Henry Wallwork & Co., Ltd., Manchester, England. In drawing the efficiency curves in Fig. 11 (September number) no attempt was made to smooth out the curves and so eliminate any inconsistencies which appeared. In the very nature of things it is impossible to obtain absolute accuracy in results where it is necessary to measure small differences of power, as in this case, especially when the speed of the instrument measuring input varies from that of the one measuring output.

I note that Henry Wallwork & Co. questions the decrease of the efficiency with decreasing load, and that their tests show entirely opposite results. It is certain that the friction of the gears does not vary directly with the tooth pressure. In other words, in wide variations of tooth pressure the friction does not vary widely. This being the case, the efficiency must increase with the load. Take an extreme case as an example: Assume that the friction does not vary at all, and is, in a given case, let us say, one horsepower. If, under these conditions the gear transmits two horsepower the efficiency would be 50 per cent. If the same gear transmitted 100 horsepower the efficiency would be 99 per cent. Of course, this is not intended to apply to any actual gear system, but is merely mentioned to illustrate the point that, in general, it should be expected that the efficiency would increase with the load until the breaking down point of the gear surface is reached.

In reference to the statement that the loads indicated were abnormal for the gears under consideration, this statement merely refers to the load to which the gears will be subjected when placed in an automobile transmission. It would be perfectly proper and normal to transmit the higher loads by means of these gears, but they are certainly in excess of what would occur in an automobile.

Providence, R. I. WILLIAM H. KENERSON

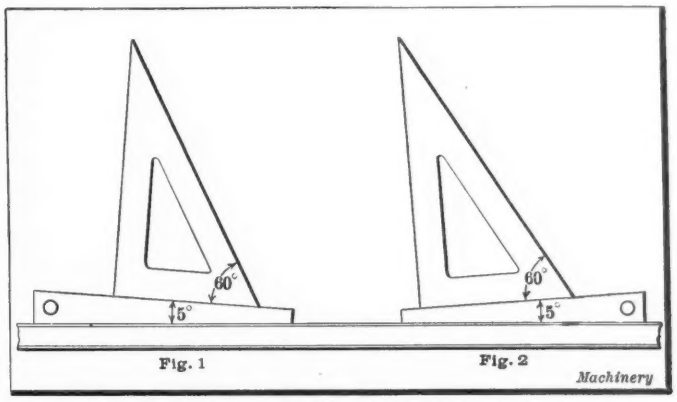
"DEVICE FOR DRAWING DOTTED LINES"

On page 215 of the November, 1912, issue of MACHINERY, engineering edition, I note an article entitled "Device for Drawing Dotted Lines." As the device referred to in said article is the subject of a patent granted to the writer (965,945, dated August 2, 1910) please print this notice in the December issue to inform your readers accordingly, so that they may avoid infringement thereof. It is the intention of the writer, who is a patent attorney, to prosecute any form of infringement of said patent to the fullest extent.

13-21 Park Row, New York BENJAMIN ROMAN

SUPPLEMENTARY ANGLE FOR DRAFTSMEN

The supplementary angle shown beneath the triangles in the accompanying illustration consists of a piece of celluloid with two of its sides or edges at an angle of five degrees to each other. With one of these angles, and the regular 45 or 30—60-degree triangles, all angles at intervals of five degrees from 0 to 360 degrees can be drawn. Fig. 1 shows the 60-degree angle combined with a 5-degree angle in such a way as to make it possible to draw an angle of 65 degrees. In



Method of using the Supplementary Five-degree Angle

Fig. 2 the 5-degree angle is reversed, making it possible to draw an angle of 55 degrees. DRAFTING ROOM

[A device of a somewhat similar nature has been invented and patented by James Dangerfield, and was described in the August, 1903, number of MACHINERY. The difference between the device here mentioned and that of Mr. Dangerfield's is that the latter consists of a set of ten angles from 1 to 10 degrees. This makes it possible to obtain accurately every whole-degree angle from 0 to 360 degrees. Sets are also made with two additional ¼- and ½-degree angles, making them practically as universal as the regular draftsman's protractor. —EDITOR.]

DRILLING HOLES IN GLASS

Occasionally we are called upon to do small jobs of drilling holes in glass. The common method known to the writer is a long and tedious process, *viz:* placing a short piece of brass tubing the diameter of the hole desired in the drill chuck and grinding the hole through the glass with powdered emery and oil. A more effective and simpler way is to take a rat-tail file about the size of the hole to be drilled and break it at about the middle so that while drilling it will not wedge the hole. Place the tang end of the file in the drill press chuck and run at high speed. Place the glass under the rapidly revolving file and let the file come gently in contact with the glass by moving the handle up and down. For a lubricant use turpentine. In this way holes are drilled in one-fourth the time required by the old method.

Chicago, Ill. O. M. HANCE

HOW AND WHY

DEPARTMENT INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST

Give details in full and name and address. The name and address will not be published with the answer.

ACTION OF BELTS WHEN THE SHAFTS ARE OUT OF PARALLEL

The answer in the October number to the inquiry regarding the action of belts on pulleys is correct in part only. The crowning of the pulley faces causes the belt to run to the "high side," that is, crowd to the center where the diameters are largest, as you state. But when the shafts are out of parallel the belt runs to the "low side," and if the shafts are badly out, the belt will run off from the low side. In other words, a high side made with a "monkeywrench" (shafts out of parallel) does not act like a crowned face. I have had many years' experience with pulleys and belts and have never known them to act in the contrary way, as described in your answer.

Amherst, Nova Scotia B. G. Cox

DIES FOR NAIL-MAKING MACHINERY

G. W. E.—I would like to obtain information on the making and tempering of dies used in nail-making machinery. At present we have to anneal, redress and temper the dies whenever they become worn, having for this purpose a gas stove with pyrometer for hardening and an oil bath with thermometers for tempering. We feel, however, that our practice is defective in comparison with that of some American firms, who we believe, regrind the cutters several times without drawing the temper. We have tried grinding the vees inside to about a fifty-degree angle, but encountered the difficulty that carborundum wheels will not keep the necessary sharp edge. Apparently it would be necessary to use a steel disk studded with diamond dust to secure the desired result by grinding.

A.—The subject is of sufficient importance to make a full reply from any reader having had general experience on the maintenance of nail-making machinery, of general interest. We will be glad to receive contributions on the subject.

STRAIGHT FACE VS. CROWN FACE IDLER PULLEYS

W. M. F.—Are idler pulleys which run on the outside of opposite side of the belts on transmission pulleys usually made with straight or crown face—and why?

A.—Practice differs. The H. W. Caldwell & Son Co. furnishes straight face pulleys for idlers. The reason given is that the driving and driven pulleys having crown faces, of course, the belt is kept in the center of these pulleys by the crowning. If the intermediate idler pulleys are also made with a crown face, and if the crown is not exactly in line with the crown of the driving and driven pulleys, there will be an objectionable moving back and forth of the belt. The Dodge Mfg. Co. makes idler pulleys both crown and straight face, depending upon the condition, but the greater part of its product is made with the crown face, and crown face pulleys are furnished when not otherwise specified. The reason given for preferring the crown face idler pulley is that it is often necessary to "lead" the belt slightly and a crown face idler assists in doing this. No objection, however, is offered to the straight face idler, and either type is furnished when specified.

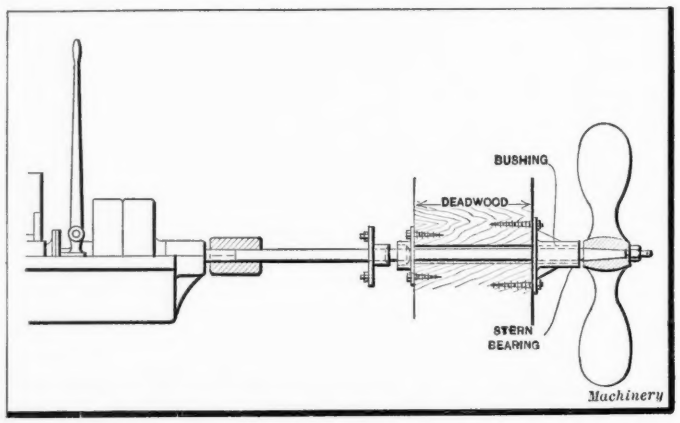
TOOLING FOR INTERCHANGEABLE MANUFACTURE

A. L. B. Co.—The question has arisen in our factory as to whether or not it is necessary to build a model machine to construct the tools, jigs and fixtures for same, provided the machine is known to be practically correct from a manufacturing standpoint, but not mathematically correct in all its parts. The machines were originally built without drawings and little by little were improved until we have a practically standard machine. About two years ago one was disassembled and drawings of the parts made, no assembly of the machine having been made or any methods used to check the accuracy of the parts. We attempted to use these drawings in conjunction with parts of the machine in making jigs and fixtures, but found that it was not feasible to proceed in this manner because of variations in dimensions of parts. The question is, how should we proceed? Do you think it necessary to build a sample machine first to check the drawings for accuracy and then make the tools and jigs to manufacture the parts?

A.—The exact procedure in tooling for manufacturing is something on which probably there would be no general agreement among toolmakers and manufacturing experts who were given the problem to solve. It would depend very largely on the type of machine, size of parts and the degree of accuracy required. In general, we would say that the hand-made machine should be disassembled and accurate drawings made of every part. No changes whatever should be made in dimensions or shapes except in those parts immaterial to the working of the machine. Having made the drawings, jigs should be made for each part using the part to get the shape, distance between holes, etc. Where great accuracy of related parts is required, and trouble in the functioning of the machine is anticipated, the jigs for the parts should be made simultaneously, and changes made if required to secure closer adjustments. Having proved the dimensions and shapes of these parts satisfactory, the drawings should be changed and corrected when necessary to agree. The work should be laid out so that the machine can be assembled, and each part checked by the pieces produced in the jigs. When the work has proceeded to the finished stage, a complete manufactured machine will have been produced from the jigs, each jig having been proved as the work proceeded. It cannot be said that this procedure would invariably result in an absolutely perfect machine, but the probabilities are that the change required would be of an insignificant character, not expensive to make. Suggestions from readers who have had experience in tooling for interchangeable manufacturing are invited.

HOW TO FIX A BUSHING ON A PROPELLER SHAFT

S. H. S.—Will you kindly advise me if there are any effective methods of fixing bushings on propeller shafts where they bear in the stern bearing of a boat? The illustration shows the manner of installation. The shafts are tobin bronze and the bushings are bronze, being from ¼ inch to ⅜ inch thick, 8 inches long on a 2½-inch diameter shaft. I have shrunk and pinned the bushings on and have sweated them on, but they all work loose sooner or later. The bushings run in lignum vitæ lined bearings or bronze bearings. The reason I have deduced for the peculiar loosening up of the bushings is that, being under water, more or less sand and dirt get into the stern bearing and quickly wear it so as to let the shaft pound or hammer, which causes the bushing to stretch and loosen on the shaft. The harder and thicker the bushings are made, the longer they last, but all of them loosen if used long enough.



A.—The oxy-acetylene process might be used to secure a sectional bushing which could be applied as a series of narrow rings and successively welded to the shaft. This method is slow and rather expensive and perhaps the readers can suggest simpler and more effective methods.

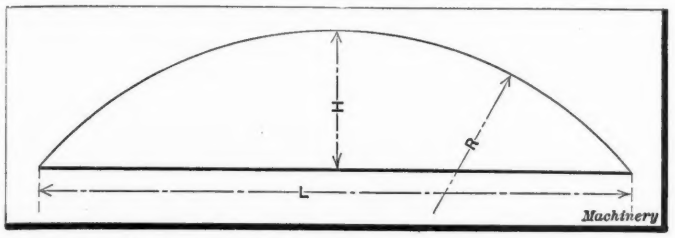
TO FIND RADIUS OF ARC WHEN LENGTH OF CHORD AND HEIGHT OF ARC ARE GIVEN

J. E. H.—Kindly give me a formula for finding the radius of a circular arc when the length of the chord and the height of the arc or segment of the circle are given, as indicated in the accompanying illustration.

A.—A formula for obtaining the radius of a segment, when the data mentioned above are given, was published in MACHINERY in November, 1906; this formula may also be found in the engineering handbooks. If L is the length of the chord; H the height of the arc; and R the radius to be found, then:

$$R = \frac{\frac{(\frac{1}{2}L)^2}{H} + H}{2}$$

This formula looks rather cumbersome and could be somewhat simplified so as to take the form:



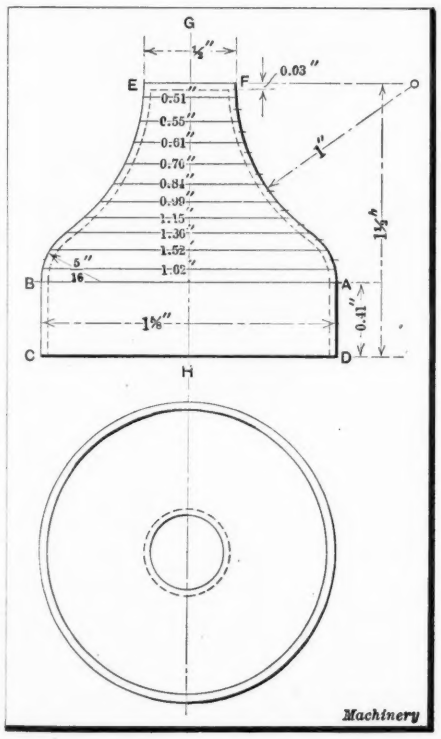
$$R = \frac{(\frac{1}{2}L)^2 + H^2}{2H}$$

The second form of the formula, however, requires more numerical calculation than does the first, which, therefore, is preferable.

TO FIND THE AREA OF A SURFACE OF REVOLUTION

R. B. H.—I would like to see a formula published for finding the outside area of sheet metal cups. An example of the kind of cups referred to is shown in the accompanying illustration.

A.—No general formula can be given for obtaining the area of a symmetrical body of the form shown in the illustration. However, the approximate area can be found by a comparatively simple method. In the illustration, the dimensions written in common fractions are the given dimensions. Those written in decimals are found by actual measurement on a figure drawn to scale. The method of finding the area is as follows: First separate such areas as are cylindrical, conical or spherical, as these can be found directly by exact formulas found in all engineering handbooks. In the example shown, *ABCD* is a cylinder, the area of the surface of which can be easily found. The top area *EF* is simply a circular area, and can thus be computed separately. The remainder of the surface generated by rotating line *AF* about the axis *GH* is found by the approximate method to be explained. From point *A*, set off equal distances on line *AF*. In the present case each division indicated is ⅛ inch long. From the central or middle point of each of these parts draw a line at right angles to the axis of rotation *GH*, measure the length of these lines or diameters (the length of each is given in decimals), add all these lengths together and multiply the sum by the length of one division set off on line *AF* (in this case, ⅛ inch), and multiply this product by π. This gives the approximate area of the surface of revolution.



In setting off divisions ⅛ inch long along line *AF*, the last division does not reach exactly to point *F*, but only to a point 0.03 inch below it. The part 0.03 inch high at the top of the cup can be considered as a cylinder of ½ inch diameter and 0.03 inch height, the area of the cylindrical surface of which is easily computed. By adding the various surfaces together we get the total surface of the cup as below:

Cylinder, 1⅝ inch diameter, 0.41 inch high,	2.093 square inches
Circle, ½ inch diameter,	0.196 square inches
Cylinder, ½ inch diameter, 0.03 inch high,	0.047 square inches
Irregular surface,	3.868 square inches
Total,	6.204 square inches

The method used in finding the area of the irregular shaped part of the cup is based on the Pappus or Guldinus rule, which states that the area of a surface generated by the revolution of a line about a central axis equals the length of the line, multiplied by the path of its center of gravity, the line being considered as a fine wire. As it is a matter of considerable difficulty to find the center of gravity of an irregularly curved wire, the simplest way in which this method can be applied is to divide the irregular shaped line into a number of parts, each one of which can be considered as a straight line, having its center of gravity at the middle of the line. In this way we find the area of each one of the divisions by multiplying the length of the division by the circumference of the circle which passes through its center of gravity. As all the divisions, in our case, were made of equal length, the simplest method was to add the lengths of all the diameters of these circles together, and then multiply by π and by the length of each division, ⅛ inch.

In testing out the accuracy of this method, the surface of a half-sphere 6 inches in diameter was found by dividing a great circle into parts ¼ inch long and finding the area by this graphical method. The exact area of this half-sphere is 56.55 square inches. The graphical method, using only an ordinary draftsman's scale, compass and triangle, gave an area of 55.28 square inches, which may be considered fairly accurate for an approximate method. The half-sphere was selected for the test case because it presents one of the difficult shapes for the application of this method, as the curved outline merges from a vertical into a horizontal direction; the surface being convex throughout, the errors are also likely to be all in one direction. A more accurate result may be expected when part of the surface is convex and part concave.

* * *

NEW ALUMINUM REDUCTION PLANT

The General Electric Co., Schenectady, N. Y., is building seven vertical water wheel type direct-current electric generators for the new plant of the Southern Aluminum Co., at Whitney, N. C. Each machine will have a rating of 5000 K. W., delivering 20,000 amperes at 250 volts at a speed of 170 R. P. M. They will be the largest direct-current machines built. Two similar direct-current generators of the same type rated at 2500 K. W. and two 1250 K. V. A. alternators will be also installed. The Southern Aluminum Co. is capitalized at $8,000,000 and will become an important factor in the production of aluminum. The plant will be in operation about the middle of 1914, and will rank among the greatest and best equipped for the manufacture of aluminum in the United States. In the complement of buildings are nine furnace rooms, wherein the aluminum will undergo the various processes incident to conversion into aluminum. Each of these structures measures 60 by 500 feet and one electrode factory of similar dimensions is also included in the group. Aluminum, because of its lightness and toughness, is becoming of more and more importance in many lines of industry. Aluminum wire and cable are displacing copper for the transmission of high tension electric energy. It is made from a clay known as bauxite, found extensively in Georgia and the Middle West. The Southern Aluminum Co. will treat only alumina which has been made from bauxite. The engineering work is in charge of Dr. Paul Heroult, a prominent French engineer.

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW DESIGNS AND IMPROVEMENTS
IN AMERICAN METAL-WORKING MACHINERY AND TOOLS

AMERICAN HIGH-SPEED SENSITIVE RADIAL DRILL

The American Tool Works Co., Cincinnati, Ohio, has added to its line the high-speed sensitive radial drill illustrated herewith. This machine is designed for drilling and tapping small holes at high speed. It is said to combine the high-speed efficiency of the plain sensitive drill with the productive capacity of the radial drill. Convenience in operating a machine of this type is an essential feature, as the actual time consumed in drilling a hole is often very small as compared with the time which elapses before the machine is set to drill the next hole. The importance of this consideration has been kept in mind in designing the present machine, and all levers and other operating members have been conveniently located for the workman, in order to simplify the operation of the machine as much as possible.

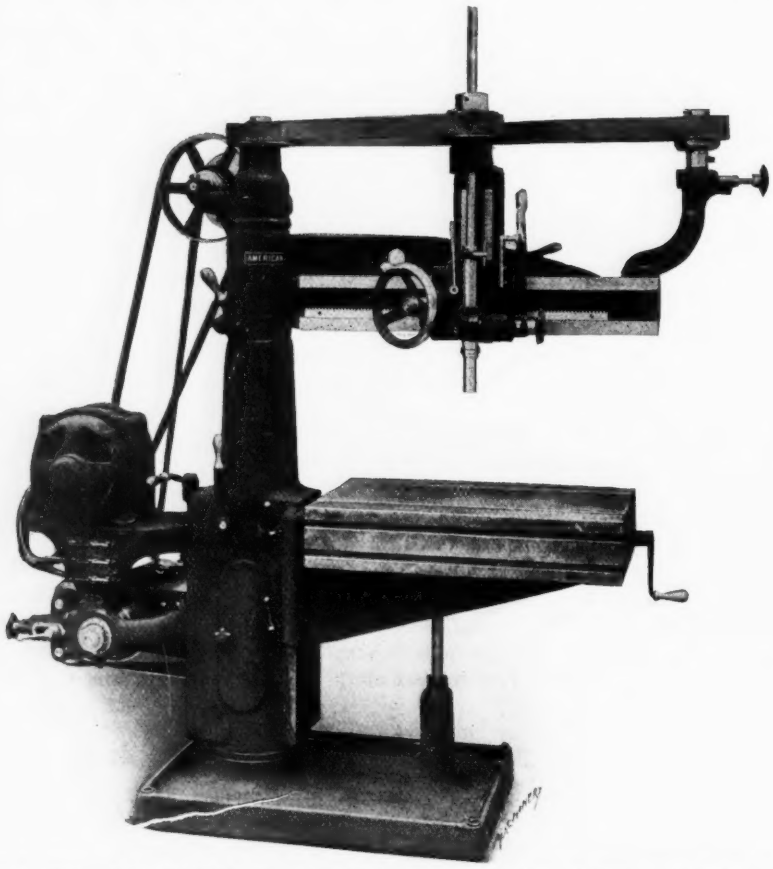


Fig. 1. Motor-driven Radial Drill equipped with Elevating Table and Tapping Attachment

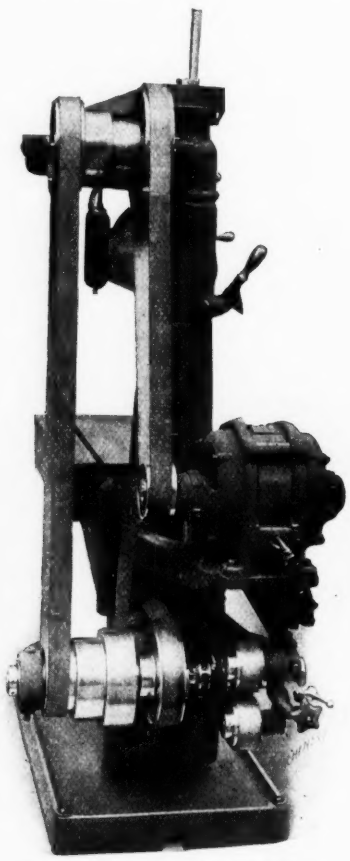


Fig. 2. Arrangement of the Drive

The feed lever is located on the head within easy reach of the workman's right hand, affording a convenient means of operation and obviating any possibility of interference with the work set up on the table. Another advantage of the ratchet lever feed used on the American sensitive radial drill lies in the fact that the lever is automatically disengaged from the rack pinion shaft when it is placed in its vertical position, so that the spindle can be quickly adjusted up and down by means of a small star knob on the end of the rack pinion shaft. This affords a rapid and convenient method of bringing the drill to and from the work.

The head is accurately balanced and can be moved rapidly along the arm by means of a rack and pinion operated by a handwheel. This handwheel is located on the front of the head on the operator's left-hand side, enabling him to swing the arm with his right hand and at the same time adjust the head along the arm with his left hand. The arm binding lever is located on the column end of the arm, where it is always within easy reach of the operator. The head is of very simple design, consisting of a main saddle which has a bearing on the arm and carries an auxiliary head upon a vertical dovetail. The sliding head is so arranged that it can be moved to or from the table, thus affording accommodation for quite a wide range of work. The auxiliary head can be securely clamped at any point along the dovetail by means of a lever conveniently located on the front of the saddle, while the head proper can be firmly bound to the arm by a lever on the back of the saddle which is within easy reach of the operator when he stands at the front of the machine.

In the elevating table type of machine shown in Fig. 1, the table is of semi-box construction, affording a large working surface. It has a bearing of ample width on the face of the column which insures a high degree of rigidity, and is equipped with a gib adjustment and two binders for locking it securely in position. The vertical movement of the table is accomplished from the front by means of a crank which imparts motion to the elevating screw through a pair of miter gears located under the table. The arm is of the American parabolic beam and tube section which has proved itself to be exceptionally rigid on the larger sizes of radial drills. Its construction is such that the lower line is parallel with the table, thus enabling the full capacity of the drill to be utilized at any point along the arm. It swings easily on the column and may be securely clamped in any position by means of a convenient binding lever. The arm does not move vertically; therefore provision is made on the head for variable heights of work.

There are no gears in the driving mechanism of this drill from the countershaft to the main spindle, the drive being effected by means of a two-inch double belt running at high speed. This drive transmits an abundance of power directly to the spindle of the drill, the spindle belt being kept at the proper tension by turning the star knob located on the arm bracket. All of the driving and idler pulleys are equipped with special ball bearings which consist of a double set of hardened and ground ball races and cones; one set is located at each end of the pulley journals. These bearings are so

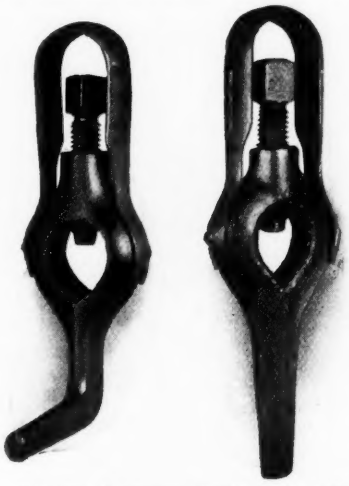
constructed that they are dustproof and form a retainer for the lubricant; vaseline or graphite is preferable for this purpose and need only be renewed at long intervals. The countershaft is especially designed for high-speed work and provides for two speeds. The hanger boxes are of an improved gravity and wick oiling type, taking their supply from large oil reservoirs and only needing attention at long intervals. The countershaft carries a three-step cone pulley with a pair of friction pulleys 10 inches in diameter and 3 inches face, and should run at 310 and 387 R. P. M.

This machine may be equipped with a tapping attachment, and with belt-driven machines so equipped a single-speed countershaft is furnished with six spindle speeds which are obtained through a three-step cone pulley and a pair of friction pulleys of different diameters located on the rear of the machine.

The spindle is of high-carbon crucible steel, accurately ground and provided with a dustproof self-lubricating ball thrust bearing. It has six changes of speed ranging from 300 to 900 R. P. M. in geometric progression, and is provided on the top with an adjustable stop-collar which may be used as a depth gage. The column is of tubular section, ribbed internally to provide the necessary rigidity. In addition to the type of machine illustrated, this radial drill is built with a stationary table, or with a pedestal base which makes it especially suited for large sizes of work. The regular equipment includes a countershaft and belts, no wrenches being required. All of the motor-driven machines are regularly equipped with a tapping attachment.

BILLINGS & SPENCER SAFETY LATHE DOG

The safety lathe dog illustrated herewith is the product of the Billings & Spencer Co., Hartford, Conn. This form of dog embodies the simplicity, strength and convenience of the ordinary dog with the additional advantage of safety. The essential parts are the same as the design which is universally used, including the regular square head, so that no special tool is required for adjustment. The guard consists of a cover for the screw which is easily manipulated, being merely pushed to one side when it is required to uncover the screw head. The guard is then sprung back into position forming perfect protection for the operator. This dog has been thoroughly tested in the manufacturers' shops and has proved efficient under all conditions.

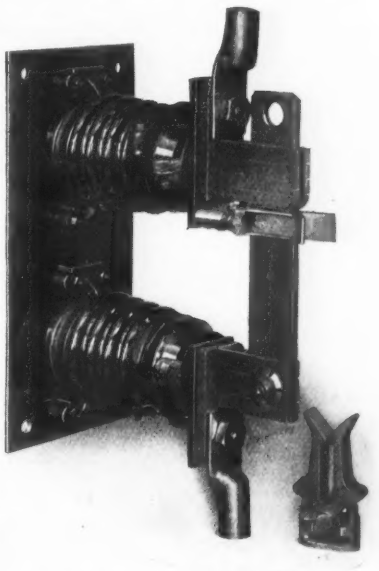


Billings & Spencer Safety Lathe Dog

LOCKING DEVICE FOR ELECTRIC SWITCHES

The locking device for electric switches here illustrated has recently been developed by the General Electric Co., Schenectady, N. Y., to eliminate the delays which are frequently caused by having machinery shut down through interruption of the power service. This device prevents the blade of a disconnecting switch from opening except where it is intentionally pulled by the operator. Instances are on record where the blades of a disconnecting switch, not protected by this device, have been thrown open or partially open by magnetic repulsion and destroyed when a short circuit has occurred on the line. In such a case, the destruction of the switch means that the circuit will be put out of commission while a new switch is being installed, unless there are duplicate circuits.

This safety locking device is a unit in itself and can be easily applied to any G. E. type L, Form G6 switch by merely clamping it to a support placed between the clip block and the insulator cap. It is designed to be operated with a switch hook and consists essentially of two brass bell cranks, hinged together at the ends of two shorter arms and held closed by compression springs. The projections or jaws in the outer ends of the two longer arms close in front of the blade, thus preventing the latter from coming out of the clips. Each bell crank is provided with a dog which moves in a slot in the bell crank elbow, the dog being hinged at this point. Two compression springs, one pressing outward from the switch base against the elbow of each crank and also against the dog, keep the bell cranks closed and the dogs pressed against the back of the switch blades.



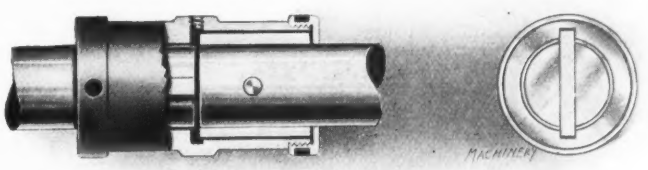
Locking Device to prevent Electric Switches from being accidentally opened

To open the switch, the outer ends of the bell crank are pressed back away from the blades, allowing the dogs to come forward and rest upon the sides of the blades; in this position they hold the jaws apart in front of the blade and allow the switch to be opened. Withdrawing the blade of the switch from between the dogs causes the jaws to automatically close against the sides of the blades and to snap shut as soon as the blade is completely withdrawn. As the outer edges of the jaws are beveled, the switch blade can be readily pressed back to the closed position between the clips, when the jaws close automatically in front of the blade, locking the latter in the closed position. The operator cannot forget to lock the switch closed because it automatically locks itself. This device is made in standard sizes to fit 300, 600, 800 and 1200 ampere switches, and can also be furnished for a switch of any other capacity.

MC EWEN IMPROVED STEEL COUPLING

A new form of flexible coupling, constructed entirely of crucible steel, has recently been introduced by McEwen Bros., Wellsville, N. Y. It is known as the McEwen coupling, and being small and consequently light in weight, it is particularly suited for classes of service in which it is necessary to reduce inertia as far as possible.

The keys extend right through the shafts and are set at right angles; provision is made to take care of a reasonable amount of non-alignment, but the ample key bearing surface and exceptionally good lubrication does away with any noise or tendency towards serious wear. This type of coupling was first used on McEwen Bros.' pumps, direct-connected to steam turbines, where it was kept in continuous service for several months at a time. The ability of the coupling to stand up under such a severe test appears to demonstrate its fitness for a variety of classes of service; such as reversible motor drive for machine tools, blowers, rotary pumps, and a variety



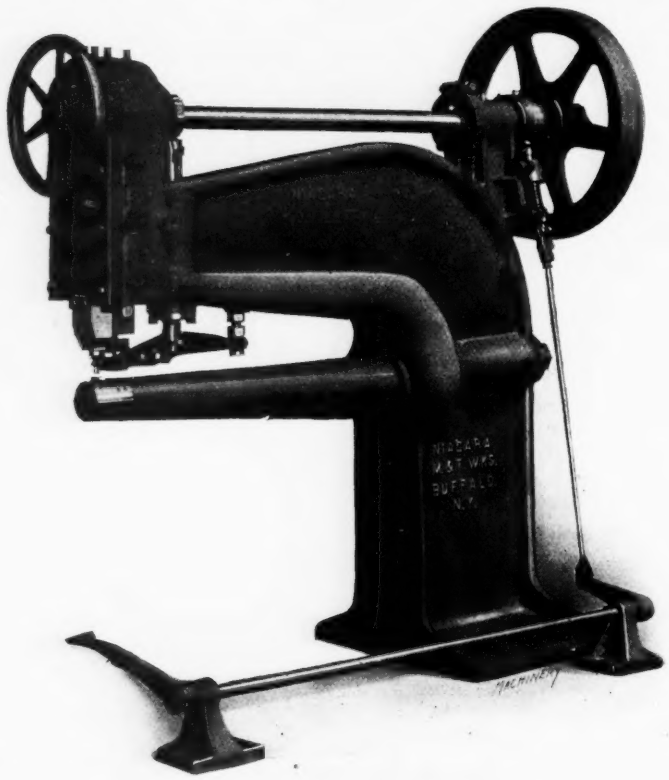
McEwen Improved Steel Coupling

of other cases where high speeds make the conditions of service particularly trying.

NIAGARA PUNCHING AND RIVETING PRESS

The Niagara Machine & Tool Works, Buffalo, N. Y., has recently added to its line the punching and riveting press illustrated below. This machine is designed to handle punching and riveting work in the manufacture of pipe, culverts, etc. Two thicknesses of material are punched and, at the same time, a rivet put in the hole punched on the previous stroke is headed, the rivet being inserted with the head upward. This method of combining riveting and punching in one operation, saves time, but is only applicable when the rivets are uniformly spaced. The distance between rivets can be varied from 1 5/16 to 2 3/4 inches.

The rivet header and punch are mounted in adjustable holders fastened to separate slides; these slides are actuated



Niagara Punching and Riveting Press

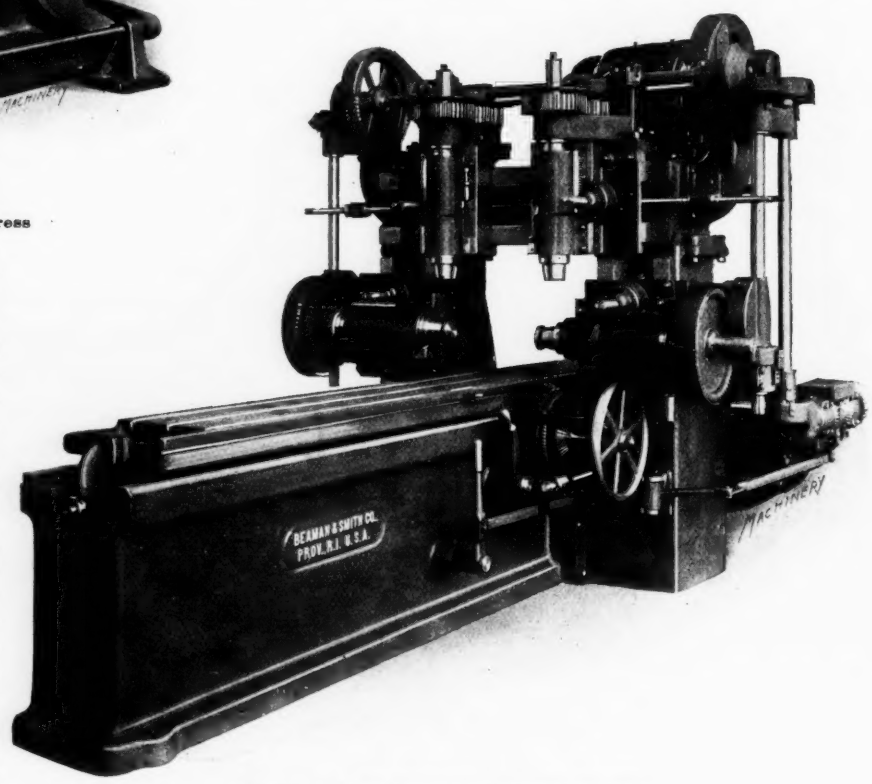
by two eccentrics and pitmans from the main shaft. It is also possible to use this machine entirely for punching holes or for riveting, or it may be used for punching and riveting alternately. When it is desired to use the machine entirely for riveting, the operator can quickly put the punch out of operation by means of a gag. When it is desired to punch without riveting, the rivet punch will run idle. The stripper or hold-down, which is actuated by a cam, clinches the material while it is being operated upon, and then strips the stock from the punch on the up stroke. The press is provided with an automatic jaw clutch and the motion of the slides can be started either by means of a hand-lever or a foot treadle. When the lever and treadle are released, the slides stop automatically at the top of the upward stroke. The machine has a throat 36 inches deep and the horn is a steel forging 5 inches in diameter at the outer end and 7 inches in diameter at the inner end. The press will upset a rivet cold up to ¼ inch in diameter, and will punch a hole ⅜ inch in diameter through ¼-inch iron or its equivalent. The gross weight of the machine is about 3600 pounds.

BEAMAN & SMITH FOUR-SPINDLE MILLING MACHINE

The four-spindle milling machine illustrated herewith is a recent design built by the Beaman & Smith Co., Providence, R. I. Reference to the illustration will show that there are two horizontal and two vertical spindles, the former having a vertical movement on the uprights and the latter a horizontal movement on the cross-rail. The table has a working surface 17 inches wide by 10 feet long; it has three T-slots finished from the solid metal and two rows of holes for stop-pins. The movement of the table on the bed is 10 feet 9 inches, and it is provided with a power traverse of 10 feet per minute in either direction. The automatic stop and feeds are arranged to maintain the desired rate at any spindle speed, which is a very important feature, as the rate of feed determines the quantity of work produced. The table is operated by a screw revolving in a bronze nut, the thrust being taken by ball bearings. Positive feeds for the table are provided by means of a geared feed-box which is conveniently located, and the change from one rate to another can be quickly obtained. There are nine changes ranging from 1 inch to 12.3 inches per minute at a driving-shaft speed of 500 R. P. M.

The spindles are of crucible steel and run in boxes of hardened bronze. They have a 6-inch independent adjustment and the ends are tapered to 3¼ inches in diameter for face milling cutters; No. 12 Brown & Sharpe taper holes are provided for cutter shanks and arbors. Each spindle has a hole through its center for the retaining bolt. The front bearings are 3⅞ inches in diameter by 5 inches in length, and are provided with means to compensate for wear. The rear bearings are 2¾ inches in diameter by 4¾ inches in length. All of the spindles are driven in unison. The gearing for the vertical spindles has a ratio of 7¾ to 1 and gives a spindle speed of 66 R. P. M. For the horizontal spindles, the gearing ratio is 21¾ to 1 and gives a speed of 23 R. P. M.

The machine is driven by a variable speed, 10-horsepower motor, geared to the driving shaft in the ratio of 3 to 1; the motor speed ranges from 500 to 1500 R. P. M. This machine



Beaman & Smith Four-spindle Milling Machine

can also be arranged to be driven by a 5-inch belt on a three-section cone with steps ranging from 11½ to 16 inches in diameter. When belt driven, the countershaft has tight and loose pulleys 14 inches in diameter and runs at 360 R. P. M.

The construction of the machine is in accordance with the latest practice. The quick running shafts are mounted in

bronze lined boxes; the bearings are finished by grinding; all sliding surfaces are scraped to an accurate fit; all gears are cut from the solid, the bevel gears being made by the Bilgram process; and many of the gears are of steel. The distance between the uprights is 30 inches; and from the ends of the vertical spindles to the top of the table, the least distance is 9 inches and the greatest distance, 15 inches; the least distance between centers is 10⅝ inches and the greatest distance, 30 inches. From the center of the horizontal spindles to the center of the table, the least distance is 4 inches and the greatest distance, 10 inches; between the ends, the least distance is 6 inches and the greatest distance, 18 inches. The weight of the machine is approximately 20,000 pounds.

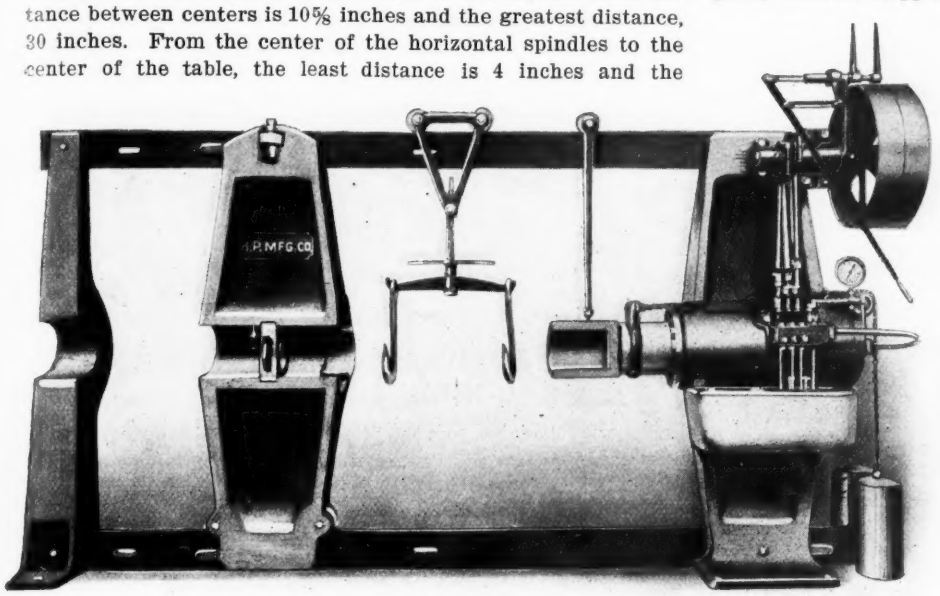


Fig. 1. Press for forcing Railway-car Wheels on and off Axles

THREE HYDRAULIC PRESSES

The Hydraulic Press Mfg. Co., 84 Lincoln Ave., Mt. Gilead, Ohio, has recently placed upon the market three hydraulic presses which are illustrated in Figs. 1, 2 and 3. The press shown in Fig. 1 is designed for forcing railway-car wheels on and off the axles, and delivers a firm steady pressure that will seat the wheel securely. Strength in all parts is obtained by the use of steel instead of iron or semi-steel. The steel cylinder is much lighter than when made of cheaper material, and is also far more dependable in service. Pressures up to 2500 pounds per square inch are available, and this is quite sufficient for the work done by this machine.

The ram has a long bearing in the cylinder which insures freedom from binding. As soon as the pressure is released, the ram is drawn back by weights and chains, and in order to enable it to withstand heavy pressure, the ram is faced with a hardened steel bearing. The resistance head is provided with a throat which serves the double purpose of a guide and stop. The parallel bars are slotted and provided with keys for shifting the resistance head to the right distance from the ram. This resistance head, in addition to the adjustable lifting hooks and hollow pressure block, shifts on the parallel bars by means of rollers. The press is operated by a motor drive or by a power attachment, with tight and loose pulleys for operating with a belt. It is equipped with from one to four pump plungers which can be arranged to drive the ram at any desired speed. The bronze pump flanges are driven by eccentrics and knockout attachments control the speed of the pump without stopping it.

The portable inverted press illustrated in Fig. 2 was built for the U. S. Government for forcing and general purposes; it is to be used at the Purdue University Experiment Station. One of its striking features is the unobstructed daylight space which makes it possible to place the press in contact with all sizes of machinery. By simply boring a hole in the platen, the press can be used for forcing wheels on and off shafts. The ram is returned by a rack and pinion which is placed back of the cylinder to be out of the way. The parts of the press taking stress are constructed of steel, the cylinder being made separate from the beam. The wheels have roller bearings which make the movement of the press from place to place an easy matter. The pump is small and compact, having a ⅝ inch piston with a 3½ inch stroke; the piston guide is made in one piece and serves the double purpose of guide and fulcrum for the pump handle. A safety valve in connection with the pump protects the frame against overload.

Fig. 3 illustrates a forming press which could also be applied to a variety of general classes of heavy work. The press is entirely above the floor line and can be easily installed. The speed of the ram in starting is increased by placing two pumps on the press. The platen, pressure head and strain rods are of steel, and are designed to withstand the great stress to which they are subjected in operation. A maximum stress of one hundred tons will seldom be exceeded in the general run of work, but a safety valve and pressure gage are provided to

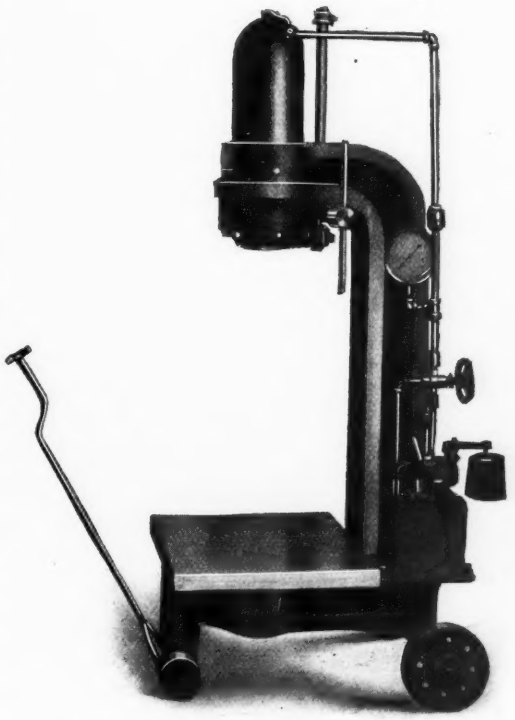


Fig. 2. Forcing Press built for Purdue University Experiment Station

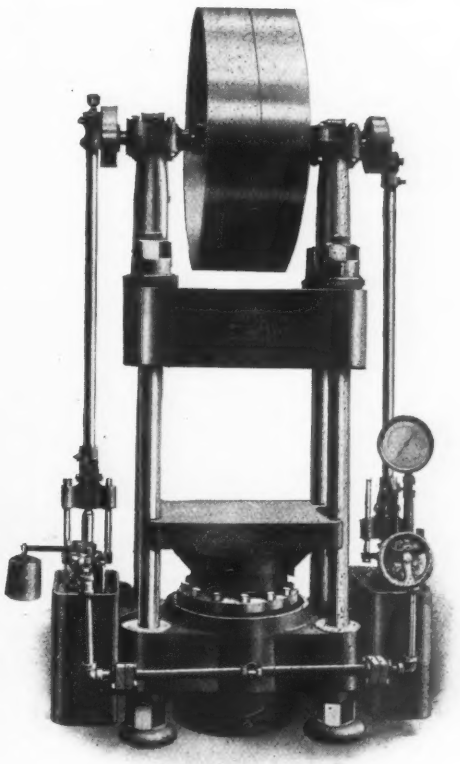


Fig. 3. Forming Press designed for Heavy Work

guard against overload. The power attachment is very simple and is located where it will not interfere with the operation of the press in any way.

EDGEMONT PLATE-TYPE FRICTION CLUTCH

The plate-type of friction clutch shown in Figs. 1 and 2 is an addition to the line of friction clutches manufactured by the Edgemont Machine Co., Dayton, Ohio. This friction clutch consists principally of three disks, enclosed in an outer casing provided with a hub on which the pulley or pulleys are held. (A two-piece sheet steel pulley is shown in place in Fig. 1). As shown in Fig. 2, the outer casing is provided with an internal rib, slotted to fit two keys formed on the "floating" disk which is faced on both sides with "burn-proof" brake lining. This central disk is free to "float," but cannot rotate independently of the outer casing.

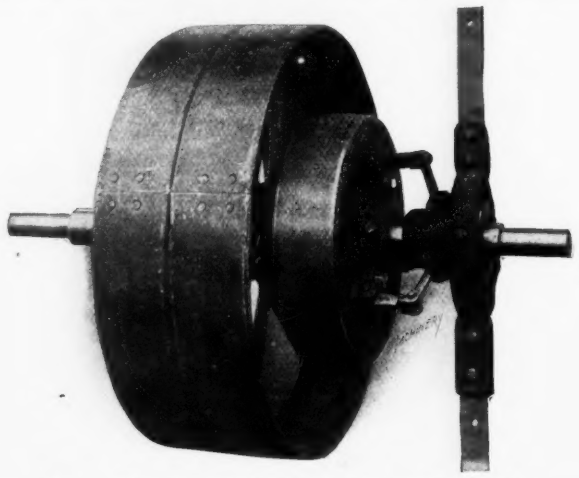


Fig. 1. Edgemont Friction Clutch with Pulley attached

The lever plate to the right (see Fig. 2), is provided with lugs, and is also furnished with a hub to which the plate to the left, is keyed, but is free to slide laterally when operated by the studs and levers shown. These two plates form the outer friction members of the clutch, and when brought into contact with the friction surfaces of the "floating" disk, rotate the outer casing and consequently the pulleys which are held on it. The lever plate which is held to the countershaft by a set-screw or key is drilled to receive three studs, provided with adjusting nuts, and held in the plate to the left. These studs are pulled out by the shoe ends of the levers which are held in the lever plate and operated by the other three levers, sliding sleeve and shifter.

Now, when the shifter rod is forced to the left, it forces the sliding sleeve inward "expanding" the levers, and through the medium of the cam ends of the levers in the lever plate, pulls out the studs, drawing the plate in and exerting a friction between the three surfaces. Then as the lever plate is held to the countershaft, it follows that all the members of the friction clutch rotate when held together by the friction exerted between their surfaces. When the shifter rod is forced to the right, the action on the levers is just the reverse of that described, and as coil springs are interposed between the inner surfaces of the two outer plates, they are automatically separated when the studs are allowed to go back. The adjusting nuts on the studs are used to give the desired amount of friction required for driving.

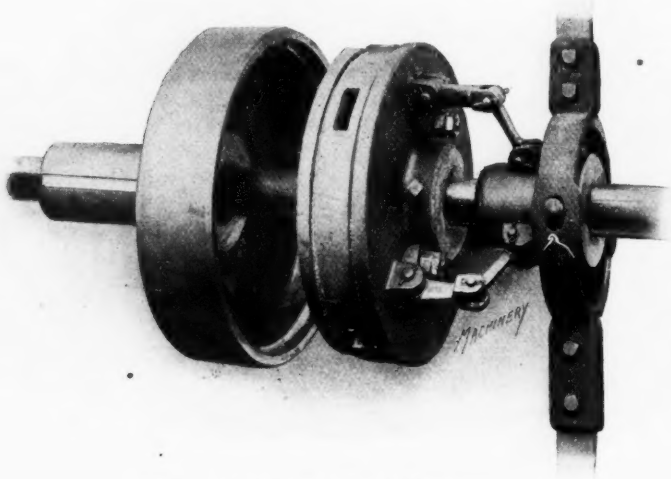
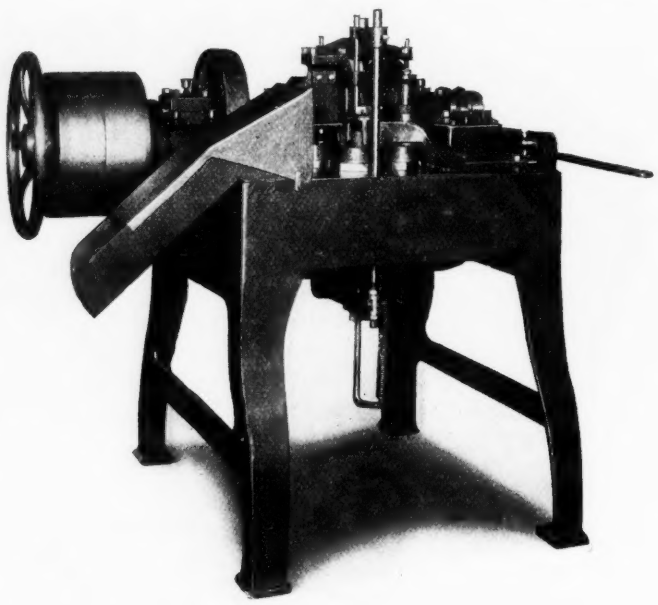


Fig. 2. Details of the Clutch Mechanism

One feature of this clutch, which is especially commendable, is that its friction plates do not require oiling. The friction lining can also be renewed without removing the clutch from the shaft. This clutch can be operated at high speeds, and is suitable for very heavy duty. It can be applied to line-shafting, countershafts, etc., and is furnished in either the extended sleeve type (shown in Fig. 2), or with the cut-off coupling; this type is used for connecting two line-shafts, and enables one section of the "line" to run while the other shaft is stationary, or when the clutch is "connected" both shafts can be rotated.

BLISS AUTOMATIC TRIMMING AND CURLING MACHINE

A special machine recently designed and built by the E. W. Bliss Co., 5 Adams St., Brooklyn, N. Y., for trimming and curling the flanges of drawn cups, is shown in the accompanying illustration. The machine consists of a vertical turret with six spindles, each of which is equipped with a chuck. The spindles are revolved continuously by spur gearing, and the turrets intermittently by a Geneva movement. The operator places a cup on the chuck as it appears in front of him; the chuck then moves in position for the trimming cutters. There are two rotary cutters which are mounted in a slide and driven by a chain and sprockets. The slide moves by cam action in toward the chuck and the flange on the cup is trimmed. The scrap is discharged through the machine.



Bliss Automatic Trimming and Curling Machine

The curling of the edge is done at the two succeeding positions. When the first of these positions is reached, the edge is started, and at the next position, it is finished. For all three positions, the blank is held onto the chuck by an upper spindle which descends and clamps the blank after it has been placed in position. The discharge of the blank is effected by means of two fingers. These fingers descend on the cup, gripping it at the edge and lifting it up until a third finger strikes it; this throws the cup in a horizontal direction into the discharge chute.

The machine is semi-automatic, as the operator simply places the cup on the chuck and the machine does the rest. The capacity is about 30,000 cups in ten hours, and it will take either straight, taper, or spherical shells up to 3 inches diameter by 1½ inch high.

BRADFORD HEAVY PATTERN LATHE

The Bradford Machine Tool Co., Cincinnati, Ohio, is building a new 18-inch heavy pattern, quick change gear lathe. One of the interesting features of this lathe (a general view of which is shown in Fig. 1) is the back-gear speed-changing mechanism. In previous designs, two friction clutches for engaging the medium and large back-gears, were placed directly on the back-gear sleeve. In this design, only one friction clutch is required, which has the advantage of engaging the higher speed of the cone, as well as giving two gear reductions for driving the lathe spindle when taking heavy cuts.

With the two-speed countershaft which is regularly furnished with the lathe, eighteen spindle speeds are available. The six fast speeds are obtained by locking the cone to the face gear and disengaging the back-gear in the usual manner. The method of obtaining the remaining twelve speeds will be more clearly understood by referring to the detail view of the headstock, Fig. 2. The cone pulley, by means of an expanding clutch ring in the left end, drives double cone gears with which the back-gears *A* and *B* are in driving connection. These latter gears afford two distinct drives for the lathe spindle, the drive being in each case through the clutch member *C*, the back-gear sleeve and pinion meshing with the regular face gear *G*. The clutch member *C* and the friction clutch member *D*, are engaged and moved simultaneously by the steel cross-piece *E*, which is caused to slide on a cylindrical stud by handle *F*, and the connecting link shown. A movement to the right or left of clutch members *C* and *D*, causes the former to clutch first with either of the gears *A* or *B*, respectively, and, in both instances, the driving cone pulley is engaged in sequence by the friction clutch ring in the end of the pulley. The two back-gear speeds are available at all times without stopping the lathe. Lever *F* is provided with stop pins which prevent the action of this lever from subjecting any of the bearings or rotating parts of the lathe to end thrust.

Aside from the back-gear mechanism, this lathe is similar in its general construction to designs previously built by this company. The swing over the bed is 20¼ inches; over the rest, 11⅝ inches; and over the carriage, 13¼ inches. The size of the front spindle bearing is 3 1/4 by 5 1/16 inches, and the rear bearing, 2½ by 3¾ inches. The back-gear ratios are 10.95 to 1 and 3.31 to 1. The lathe will cut threads ranging from 3 to 46 per inch, including 11½ pipe threads. The spindle is made of high-carbon crucible steel and is mounted in adjustable taper bronze bearings. It extends through the hood, allowing the use of draw bars and tubes for drawing attachments. The bed is of extra weight and depth and is webbed in two-foot sections, which gives great rigidity.

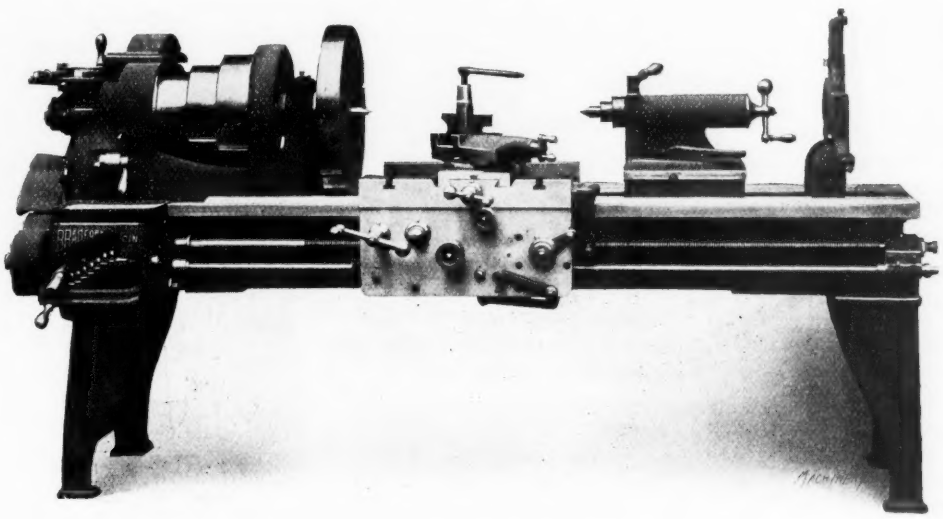


Fig. 1. Bradford 18-inch Lathe with Friction Double Back-gears

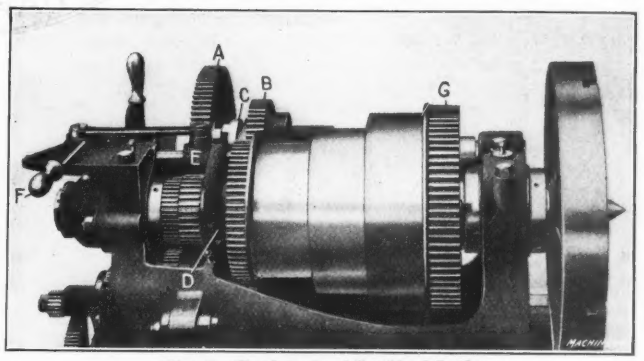


Fig. 2. Headstock of Bradford Lathe

LA SALLE COMPENSATING QUADRANT CRANE

A one-ton "compensating quadrant crane" now being built by the La Salle Machine & Tool Co., La Salle, Ill., is shown in Figs. 1 and 2. This crane was designed for service on trucks and, at the present time, is made without a turntable; that is, the crane cannot be swung horizontally. A turntable, however, which will swing from 180 to 360 degrees, can be supplied. The lower end of the boom of this crane is segment shaped and has shrouded teeth which engage corresponding rack teeth on the base. These gear teeth are shrouded to the pitch line, not so much for strength, as to provide a rolling bearing for taking the vertical thrust due to the weight of the boom and load. The shrouding is machined on the outer surface, and the gear teeth are relieved of all vertical bearing stresses.

The position of the boom is changed by turning the crank and pilot wheel shown. The motion of the crank is transmitted to the screw through gunmetal bevel gears having a ratio of

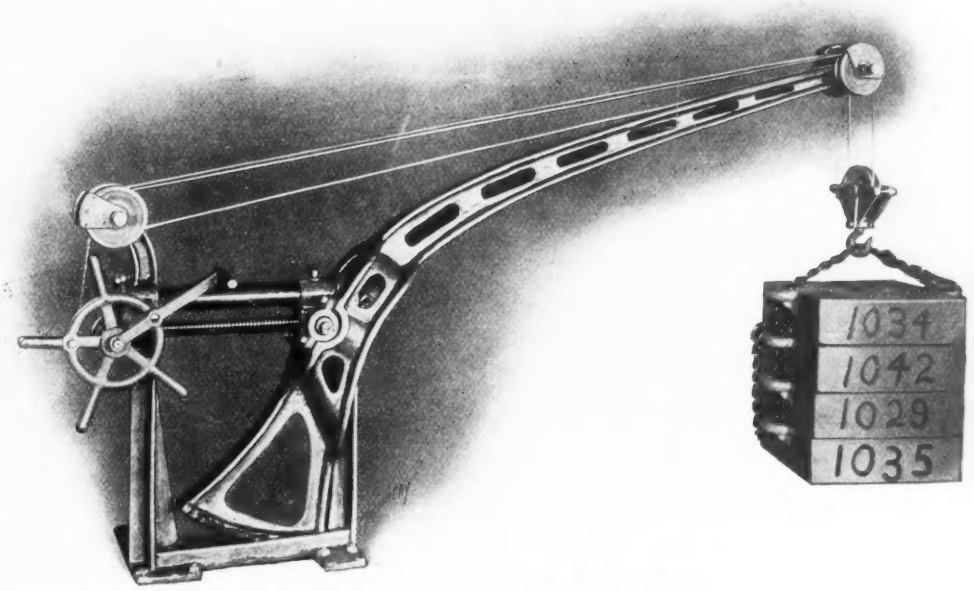


Fig. 1. La Salle One-ton Crane with Boom lowered

1½ to 1. The screw, in turn, engages a nut that is trunnioned in the boom and slides along a cylindrical rod above the screw. With this construction, one man can raise a load of one ton from the lowest to the highest position in thirty seconds.

Because of the compensating feature of the crane, the thrust on the screw is very slight and in some positions of the boom, the thrust is practically eliminated. The load also remains at about the same level whether the boom is in its lowest or highest position. The hoisting cable can be operated either by an electric hoist, in case the crane is mounted on an electric truck, or by a hoist designed to be driven directly from the transmission of a gasoline truck.

The frame, boom and nut are made of open-hearth steel castings. The tie-rod upon which the nut slides is made of cold-rolled steel covered with brass tubing. The screw is made of

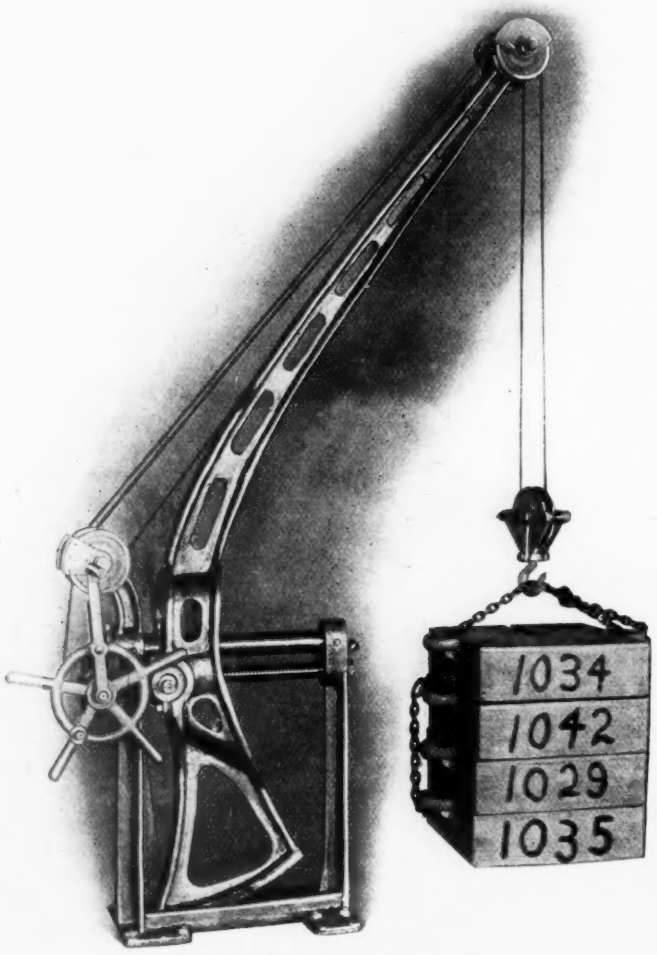


Fig. 2. La Salle Crane with Boom raised

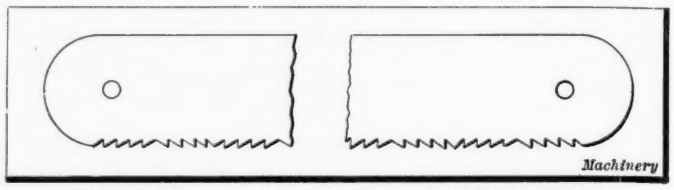
30 per cent nickel steel to avoid corrosion and is mounted in self-aligning radial and ball thrust bearings. The nut is lined with phosphor-bronze.

The figures on the weights (see illustrations) show the test load used on this crane. With this load, it is possible for one man, by means of the crank, to raise the boom from the lowest to the highest position without over-exertion. This crane has a maximum reach from the front of the frame, of 7 feet, and a minimum reach of 2 feet. The maximum and minimum heights are 9 feet 10 inches and 6 feet 2 inches, respectively.

REITLINGER DOUBLE-ACTION HACKSAW BLADE

A new type of hacksaw blade, recently placed on the market by Alex. Reitlinger, 201 William St., New York, is shown in the accompanying illustration. The design of this saw is decidedly novel. The teeth are arranged in groups of four, the teeth of each group being set in the opposite direction to those of the adjacent groups. The idea of this design is that the saw may be made to cut on both forward and return strokes. It will, of course, be evident that this type of saw is driven by a machine which is not equipped with means for lifting it out of engagement with the work on the return stroke.

It is claimed that the ability to cut on both the forward and return strokes gives this saw a materially increased cutting capacity. An idea of the capacity may be gathered from the fact that, in a recent test, a piece of 1½-inch steel shafting was

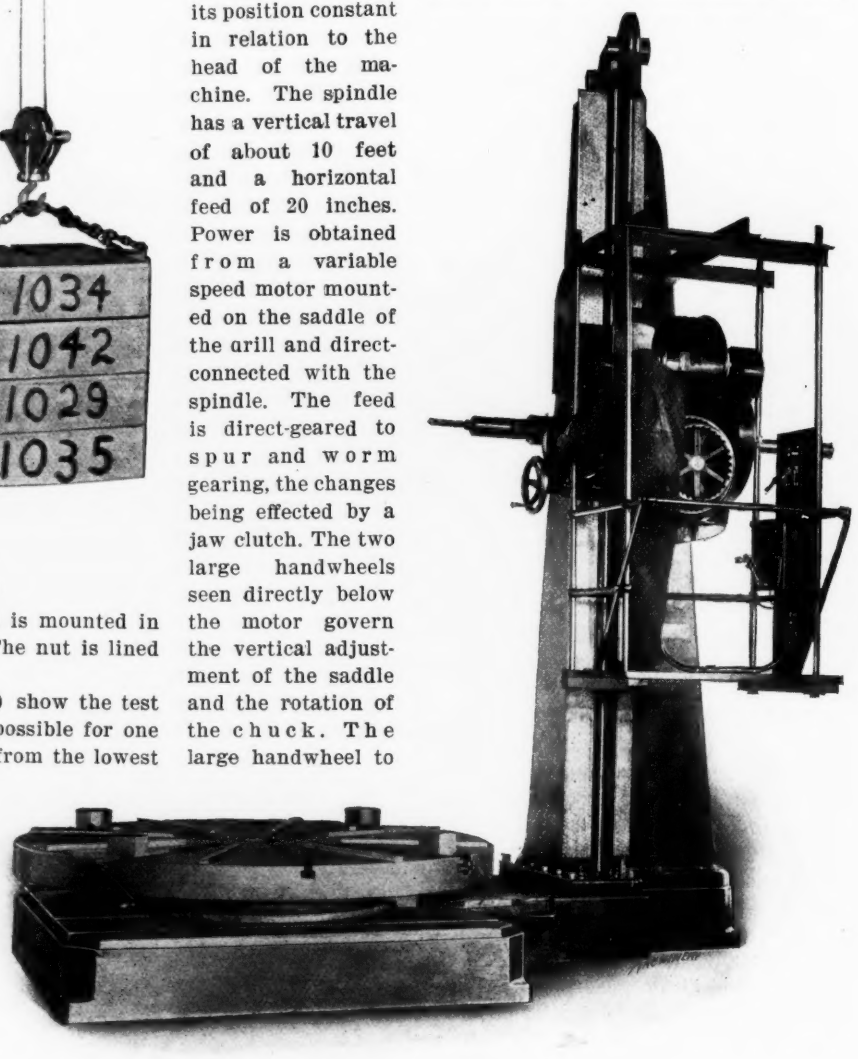


Hacksaw designed to cut on Both Forward and Return Strokes

cut in three minutes and thirty-three seconds. These saw blades are now being made ½ inch in width with 16 teeth to the inch. It is also intended to make saws of this design having 11, 24 and 32 teeth to the inch; this range will provide for making saws of all necessary sizes for different classes of work.

BAUSH BOILER SHELL DRILLING MACHINE

A boiler shell drilling machine, in which the shell is held in a four-jaw universal chuck after being rolled and may be rotated from the operating position of the drill, is one of the latest products of the Baush Machine Tool Co., 200 Wason Ave., Springfield, Mass. The operator stands in a cage (see accompanying illustration) which moves on the column to keep its position constant in relation to the head of the machine. The spindle has a vertical travel of about 10 feet and a horizontal feed of 20 inches. Power is obtained from a variable speed motor mounted on the saddle of the drill and direct-connected with the spindle. The feed is direct-geared to spur and worm gearing, the changes being effected by a jaw clutch. The two large handwheels seen directly below the motor govern the vertical adjustment of the saddle and the rotation of the chuck. The large handwheel to



Baush Boiler Shell Drilling Machine

the left controls the quick adjustment of the spindle and the small one in front of it governs the clutch. The handwheel on the shaft parallel with the spindle provides for a hand feed for hand drilling or facing.

The machine is provided with roller and ball bearings

throughout so that its operation is extremely light and sensitive, although the machine itself is of extremely massive construction, having a gross weight of approximately 30,000 pounds. The saddle is accurately counterbalanced and is raised and lowered by means of a screw which precludes the possibility of its dropping. The chuck has a capacity for shells ranging from 36 inches to 72 inches in diameter and up to ten feet in length; by reversing the work end for end, the capacity of the machine may be increased for work 20 feet in length. The chuck and its operating mechanism is a self-contained unit, so that the chuck may be lifted off the table and replaced again without the necessity of adjusting any gearing. The screws are equipped with ball thrust bearings which makes them easy to operate. The table is provided with T-slots so that it may be used for strapping down ordinary pieces to be drilled.

The machine stands 16 feet 1½ inch in height and the overall length is 14 feet. The top working surface and bed is approximately 7 feet square.

SHAW FIXED-TONGUE SWITCHES FOR MONORAIL CRANE SYSTEMS

An important improvement in the construction of monorail crane systems, in the form of a fixed-tongue track switch, has recently been made by the Shaw Electric Crane Co., Muskegon, Mich. The advantage of this fixed-tongue switch over the old-fashioned moving-tongue type, lies in the fact that it does not have to be set for the desired direction of travel. As the name implies, there are no moving parts to this switch, but it is still possible for the operator to select his route.

As the fixed-tongue switch does not have to be set for a change of direction, there is neither delay nor expenditure of effort for this purpose. Trolleys run through the track switch in all directions without stopping, and as there are no open ends of track, a serious source of danger has been eliminated. Reference to Fig. 1 will show that the two I-beams constituting the main or straight-through track and the third I-beam constituting the spur or curved track, terminate near the point of tangency of their center lines, and have a cast-steel extension piece or tongue rigidly secured to them. The projecting portion of this tongue is on the same level with the bottom flange of the I-beam and is a continuation of it. The tongues are so shaped that open slots are left between them through which the truck sides of the trolley pass in moving over the switch.

When the operator approaches the track switch at which he desires to run from the main line to a spur track, he pulls the steering lever which is located on the trolley near the controllers. This raises a horizontal roller to a position in which it engages a curved rib on the under side of the central tongue switch; the leading truck then swivels and is diverted onto the spur track. The trailing truck is guided onto the spur track by a positive and very simple means which is not dependent upon any action taken by the operator. No steering is necessary to return from the spur to the main line or to run through a switch on the main track in either direction.

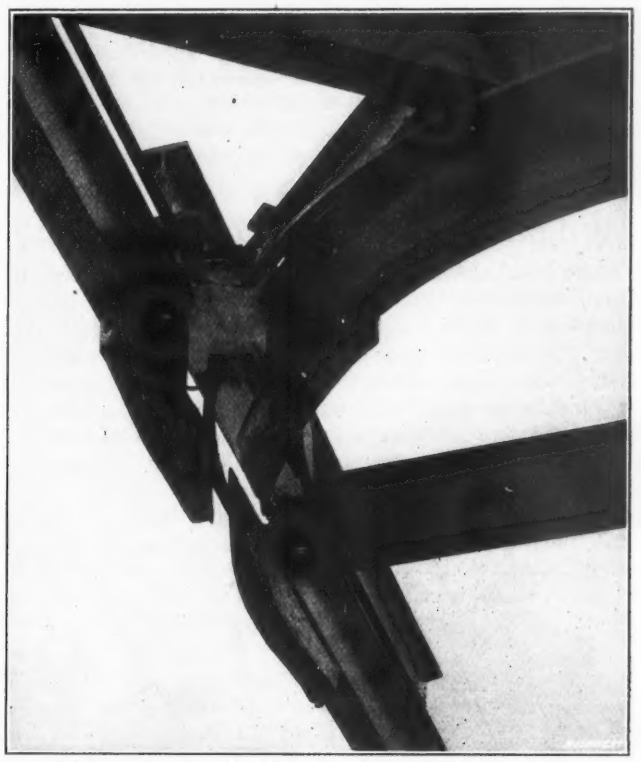


Fig. 1. Arrangement of the Shaw Fixed-tongue Track Switch

The details of the trolley design have been carefully worked out to secure a maximum efficiency of operation. Steel is employed in the construction of the main frame, the truck sides, the gears, and in all other parts where the weight of the load becomes effective, except in the rope drum and other compression members. The sizes of wire rope employed are especially liberal in proportion to the load, and the hook is a steel drop-forging which swivels on a ball bearing. Convenient

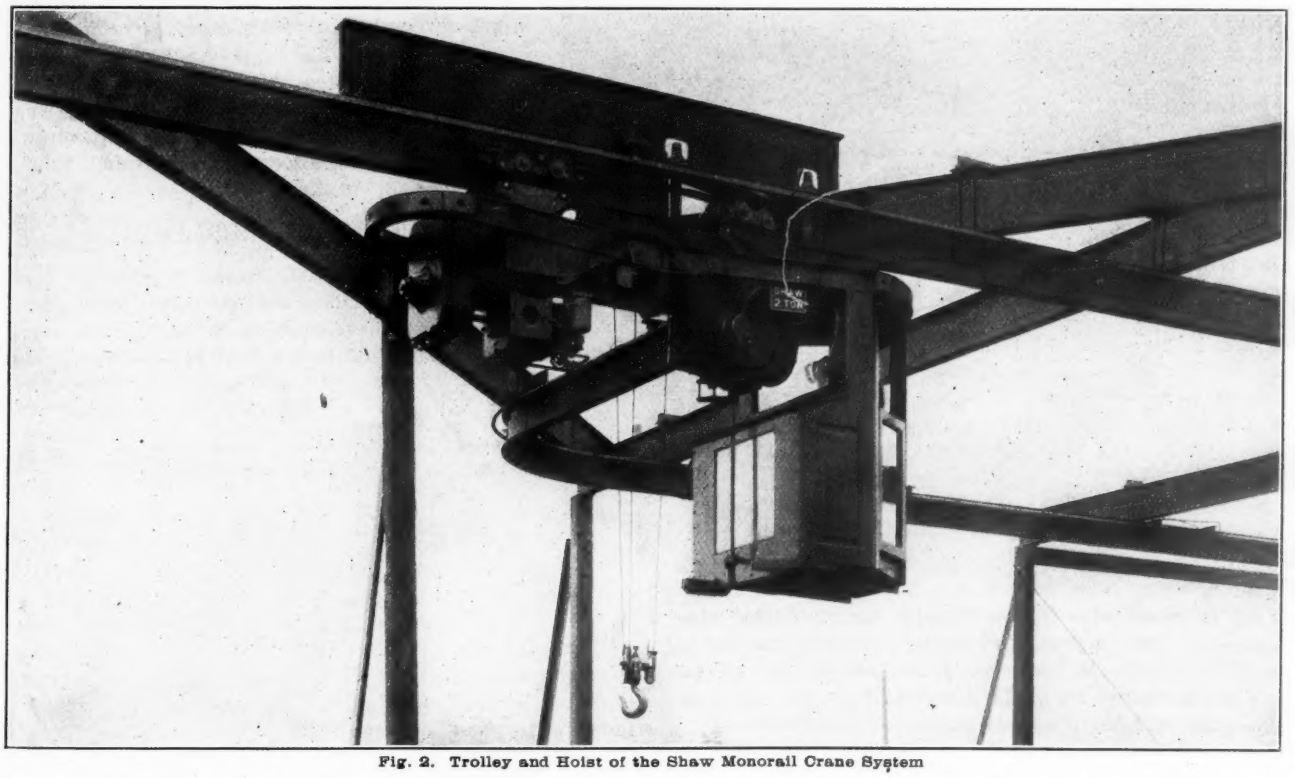


Fig. 2. Trolley and Hoist of the Shaw Monorail Crane System

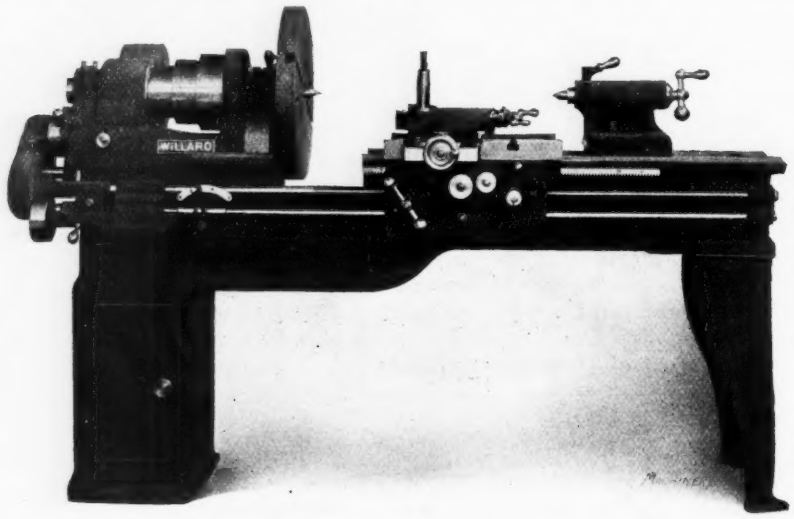
facilities have been provided for inspecting all internal parts without undue loss of time.

Curved buffers are provided at both ends of the trolley, forming a simple provision against collision with other trolleys, whether on curved or straight sections of the track. The hoist is equipped with motor and load brakes, the latter being of the multiple disk type and located in the hoist gear case. An automatic limit switch is also provided to prevent the lower block from being accidentally wound up into the trolley machinery. The motors have been designed especially for monorail work and embody the latest features applied for this class of service. The cage is arranged with a seat for the operator and all appliances necessary for giving him the requisite control over the crane.

WILLARD GAP-BED ENGINE LATHE

The gap-bed engine lathe illustrated herewith is built by the Willard Machine & Tool Co., Cincinnati, Ohio. This lathe is so designed as to make it suitable for both jobbing and manufacturing purposes. By removing the filling piece from the bed, the lathe may be made to handle work 21 inches in diameter up to 6½ inch face. When the filling piece is replaced, the lathe is transformed into a standard engine lathe which swings 13½ inches over the shears and is just as convenient to operate as any standard lathe of this type.

The headstock is of massive construction having a bearing of 21½ inches on the bed. The spindle is made of 60-point



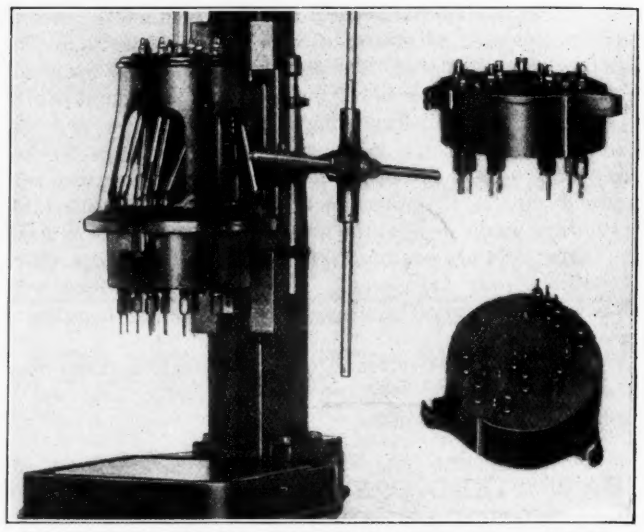
Willard Gap-bed Engine Lathe

carbon crucible steel; the front journal is 2⅜ inches in diameter by 4 inches in length, and the rear journal is 1 13-16 inch diameter by 3 inches in length. The bearings are of phosphor-bronze, carefully scraped to fit the spindle. The hole through the spindle is 1 5-16 inch in diameter, and is bored to fit a bushing for a No. 3 Morse taper. The tailstock spindle is 1¾ inch in diameter, the tailstock having a travel of 5¼ inches.

The carriage has a bearing 18 inches long on the V's. The bridge is 7¼ inches wide, and is equipped with a dial for use in screw cutting. The compound-rest is of new design, being unusually large and of particularly rigid construction. The crank handle for moving the carriage is at the left-hand side of the apron, which is an unusual arrangement for a gap-bed lathe. This handle is usually located at the right-hand side of the apron, where it is inconvenient for the operator to use it. A gib is attached to the carriage at the right-hand side of the apron for the purpose of stiffening it when it overhangs the gap. This lathe is furnished with 6, 7, 8, and 10-foot beds. It has a cabinet leg under the headstock end, an extra large faceplate, and the filling piece previously referred to, as part of its regular equipment. A cabinet leg for the tailstock end can be furnished as an extra.

CLUSTER BOXES FOR "NATCO" MULTIPLE-SPINDLE DRILLERS

The illustration presented herewith shows the head of a No. 9 multiple-spindle drilling machine, made by the National Automatic Tool Co., Richmond, Ind., equipped with a cluster box. Two other forms of cluster boxes are shown at the right-hand side of the illustration. These cluster boxes, or



"Natco" Drilling Machine equipped with a Cluster Box or Multiple Drilling Head

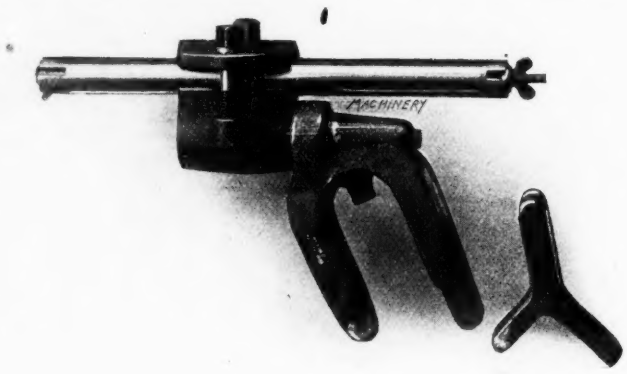
drilling heads, are used for special jobs of multiple drilling; they are made interchangeable, different cluster boxes being used for each class of work.

The boxes are driven by universal-joint spindles or a center-shaft drive. The universal-joint spindles can be detached quickly and are recommended in preference to the center-shaft drive. One reason for this is that it often makes it possible for simpler boxes or heads to be used. The universal-joint spindles also enable the adjustable rails to be used on the same machine.

With the cluster box equipment, a larger number of holes can be drilled than is possible when the machine is equipped with adjustable rails. The head has a circular range of 8⅜ inches, and the use of special cluster boxes enables this range to be increased. The machine is equipped with adjustable stops so that holes of predetermined depth can be drilled. The machine on which these drilling heads are used is the same as that illustrated in the New Machinery and Tools section for November, except that the one previously described was equipped with eight adjustable steel rails for carrying the drill spindles.

KRIEGER TOOL-HOLDER

The Krieger Tool & Mfg. Co., Grand Rapids, Wis., has recently placed upon the market the tool-holder shown below. The design has been developed to eliminate the spring which occurs with many other types of holders when taking



Tool-holder adapted to the Requirements of Heavy Work

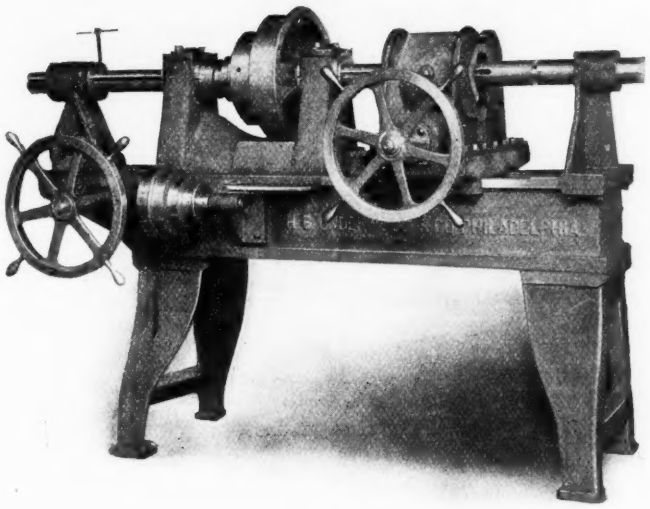
heavy cuts. It will be seen from the illustration that this holder has two shanks, only one of which need be used on light work. For heavy work, the ring is taken off the toolpost. One shank of the holder is then placed on each side of the tool-

post and the Y-shaped clamp goes through the slot in the tool-post. The three ends of this clamp engage with the shanks of the tool-holder, which is held securely in place when the set-screw is brought down upon the Y-clamp.

This tool-holder can be adjusted one inch below or one inch above the center of the lathe, and has been found particularly suitable for boring operations on stuffing-boxes and other classes of work where holes of different diameters are required.

UNDERWOOD ARMATURE AND AXLE BEARING BORING MACHINE

The machine illustrated herewith is a recent product of H. B. Underwood & Co., 1024 Hamilton St., Philadelphia, Pa., and is designed for boring the babbitted bearings of axle



Underwood Armature and Axle Bearing Boring Machine

and armature shafts of the Westinghouse and General Electric motors used in electric car service. In addition to this work, the machine can be used for boring a variety of work such as large pulleys, etc. The design of this machine enables it to be operated by unskilled labor.

The handwheel toward the right operates a powerful self-centering chuck which holds and centers split or round bearings in correct alignment with the boring-bar, no particular skill being required to do this work both accurately and rapidly. The jaws of the chuck will take bearings ranging from 4 to 12 inches outside diameter, and special oil grooves can be cut in a bearing after the box is bored. The cutting tool is held directly in the bar, the latter being of ample strength to bore with a single-ended cutter. In order that extremely accurate boring may be done on bearings of harder material than babbitt, an outboard support and extension bar are provided.

The bearings in the headstock are made to compensate for wear without changing the alignment of the spindle, and wide-faced pulleys make it possible to bore large sizes of work without the use of gearing. The feed is automatic, with three changes, and there is a hand control with provision for a quick return of the spindle. It has been possible to shorten the bed of the machine through the provision of means for telescoping the feed mechanism under the headstock, the headstock forming a cover for the slide. During a recent test, a split babbitt-lined bearing of 5 inches bore and 11 inches length was bored out in less than one minute.

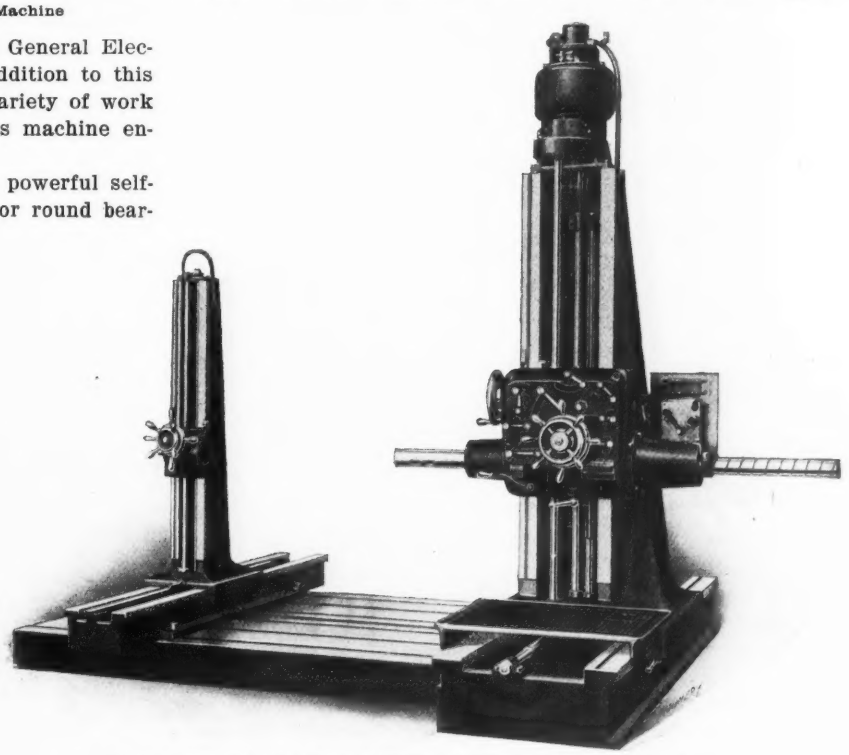
ROCHESTER BORING, MILLING, DRILLING AND TAPPING MACHINE

The Rochester Boring Machine Co., Rochester, N. Y., has brought out a new design of boring, milling, drilling and tapping machine. The operating levers and handwheels are located on the saddle within easy reach of the operator, so that the machine is convenient to work, and all changes of feed, speed and traverse in all directions, are obtained from a convenient position. The machine can be quickly started, stopped or reversed, independently of the motor or main drive. The saddle is of box construction, and is so designed that the entire operating mechanism is readily accessible.

The machine is regularly equipped with electric motor drive. The constant-speed motor is mounted on top of the column where it is out of the way of chips and dirt, and drives the vertical shaft, which transmits power to the driving mechanism enclosed in the saddle, through rawhide gearing. This arrangement simplifies the drive and gives a high power transmission efficiency. When belt drive is preferred, the machine is driven by a single pulley at the rear of the bed, the pulley being mounted on a splined shaft, which operates the vertical driving shaft in the column through bevel gears. The driving pulley is equipped with a clutch for starting, stopping and reversing.

The spindle is made of hammered, high-carbon crucible steel, and it is journaled in long taper bearings of phosphor-bronze, which are adjustable from the side and located at each end of the saddle, so that they are far enough apart to give a rigid support to the spindle. The feed and drive are applied between the bearings, the spindle being driven by two large spline keys fitted into a steel sleeve on which the driving gear is mounted. This sleeve is journaled in independent bearings, and clearance is provided between the sleeve and spindle to eliminate any vibration from the driving gears.

The concentric screw feed allows full traverse to be obtained without resetting. The method of feeding is through a long bronze nut engaging a square thread on the spindle. The nut only comes into contact with the sides of this thread and engages with the thread for the full length of the nut, so



Rochester Combination Boring, Milling, Drilling and Tapping Machine

that an ample bearing surface is secured. The end thrust in either direction is taken on ball bearings of large diameter. The nut rotates at the same speed as the spindle when the feed is disengaged, and when the feed is applied, it is rotated faster than the spindle, according to the change-gear that is engaged; if the feed is reversed, the nut rotates slower than the spindle. This differential speed between the nut and spindle gives feed in either direction. The bar is controlled through positive planetary gearing by means of a handwheel, whether running or at rest.

A wide range of feeds and speeds is provided to meet all

requirements. The vertical milling feeds are provided for the saddle, and horizontal milling feeds for the column, independent of the boring feeds. All feeds are reversible and any desired change can be instantly obtained. The range of speeds can be readily changed to meet special requirements, giving faster or slower speeds of the same relative ratio. The power rapid traverse for the saddle, column and spindle is independent of the feeds. The power rapid traverse and feeds cannot engage together, and automatic limit stops are provided for every traverse in every direction.

GARDNER DISK AND RING WHEEL GRINDER

Fig. 1 illustrates a special disk grinder which is interesting because it is said to be the first disk grinder built with two spindles set parallel with each other. The rear spindle is mounted in the solid base of the machine and driven by a pulley belted to the countershaft in the usual way; this spindle has no lateral movement. The front spindle is driven from a pulley on the outer end of the rear spindle, a weighted idler being provided to maintain the required tension on the short

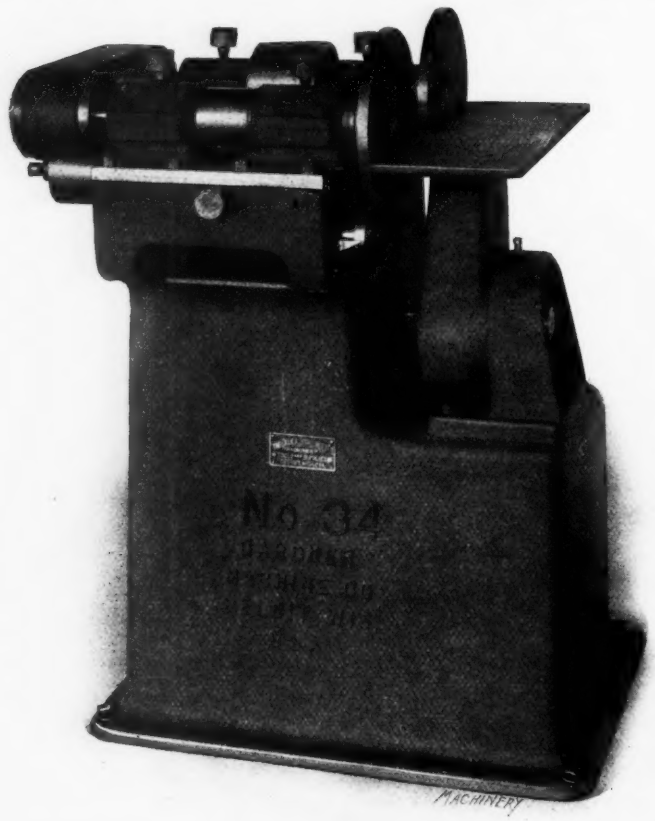


Fig. 1. Disk Grinder for finishing Parallel Surfaces in Different Planes

connecting belt. The front spindle is mounted in a head provided with a lateral adjustment which can be accurately regulated by means of the graduated handwheel shown beneath the front disk wheel. The table for supporting the work can be swung across the face of the wheel, but it is generally kept fixed in the position shown in the illustration. The purpose of this machine is to provide a rigid and accurate method of finishing two surfaces which must be parallel with each other, but in different planes. The method of regulating the adjustment of the movable spindle is particularly useful when it is required to have these surfaces at an exact distance from each other.

The novel features of the machine shown in Fig. 2 are the water shields and the angle-plates for holding the work on the lever feed tables. The hoods are of simple construction; they can be readily removed when adjusting or changing the ring wheels, and give free access at both sides for setting the work on the holder. It has been found that the wheels can be flooded with water when running at high speed, the pump for this purpose being set at the rear of the machine. The operation of the hoods is so efficient that scarcely a drop of water is thrown outside of the guards. The special angle-plates on which the work is held are provided with raised edges at the back and sides; these edges catch all water falling on the plate and return it to the pump. It is said that this

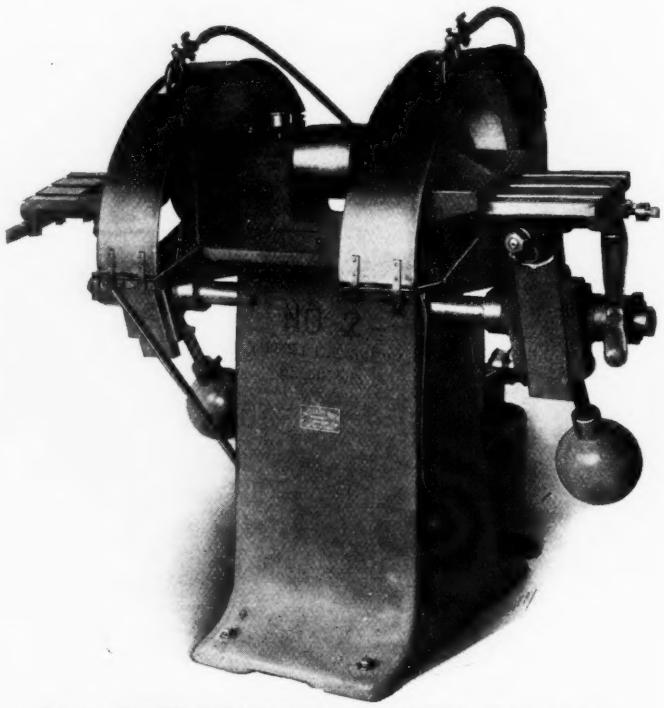


Fig. 2. Ring Wheel Grinder with Water Shields and Angle Plates for holding Work

equipment affords a particularly satisfactory method of applying water to grinding machines of this type. These machines are the product of the Gardner Machine Co., Beloit, Wis.

CALCULATING CHART

The accompanying illustration shows an interesting calculating chart that has been brought out by Mr. George M. Purver, 146 E. 8th St., Brooklyn, N. Y., for facilitating multiplications and divisions in cases where exact results are required. The slide-rule, as is well known, gives only exact

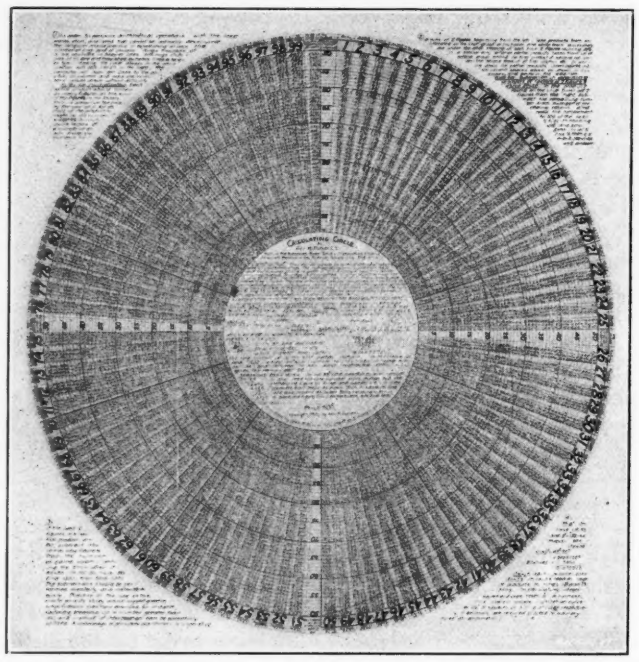


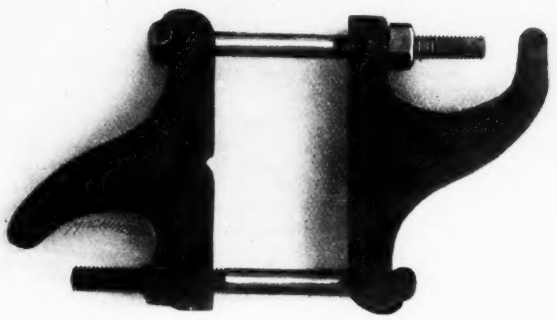
Chart for Rapid Multiplication and Division—Actual Diameter, about 15 inches

figures to very few places, and while it is satisfactory for most practical calculations where the assumed values themselves are approximate, there are conditions when the exact product is required. It is for cases of this kind that the calculating chart has been prepared. It gives instantly the product of all numbers of two figures only, and the product of a number of two figures with a number of four figures with

a slight calculation, which by training can easily be performed mentally. From a mathematical point of view the arrangement is rather unique, and there are several interesting points in the working out of the chart. Of course multiplications of numbers with any number of digets by other numbers of any number of digets can also be performed by writing down the results of the multiplication of any two figures by any other two figures, which shortens considerably the ordinary work of multiplication.

MICHAUD SAFETY LATHE DOG

The safety lathe dog illustrated herewith has recently been placed upon the market by Elmer J. Michaud, Willimantic, Conn. The clamping members of this dog are drop-forgings, held together by bolts in the manner shown. It will be seen

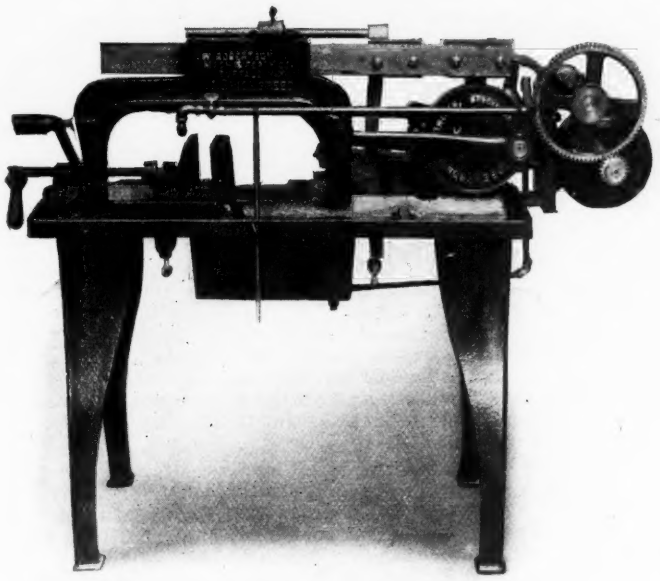


The Michaud Safety Lathe Dog

that the clamping members are provided with curved extensions which come out over the exposed ends of the bolts. The dog is mounted so that these extensions revolve ahead of the bolts, making it practically impossible for the operator's clothing to be caught or for him to be injured by the sharp edges on the bolt and nut.

ROBERTSON MOTOR-DRIVEN POWER SAW

The W. Robertson Machine & Foundry Co., Buffalo, N. Y., has recently equipped its No. 3 Economy power saw with a direct-connected motor drive. The method of attaching the motor to the saw frame is shown in the illustration, no drilling of extra holes being required for mounting it in place. The motor is back-geared and is a self-contained unit of standard



Robertson Economy Power Saw No. 3 equipped with Motor Drive

make; it is compound-wound and no starting box is required.

This machine cuts on the draw stroke and is equipped with this company's standard mechanical lift for the return stroke, which raises the blade from the work and greatly reduces the strain which it experiences in service. The maximum cutting capacity is 6 by 6 inches and the machine is so arranged that 10-, 12-, or 14-inch blades may be used. A friction band clutch in the driving gear provides for starting, and an automatic stop throws out the drive when the cut is completed. A rotary brass pump is used for pumping the lubricating fluid from the tank to the blade.

ROCKFORD HIGH-DUTY PRESS WITH AUTOMATIC BRAKE

The illustrations show a high-duty press manufactured by the Rockford Iron Works, Rockford, Ill., and also the patented automatic brake with which this machine is equipped.

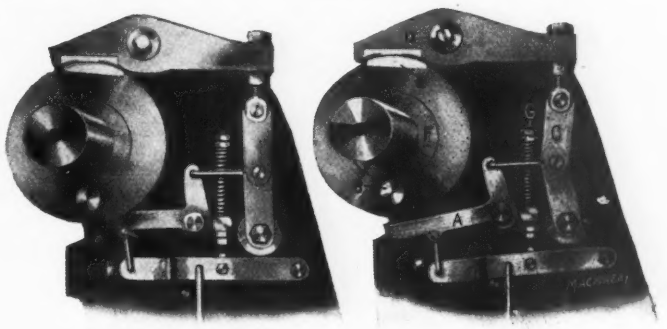


Fig. 1. Brake Mechanism of Rockford High-duty Press in the "Engaged" and "Released" Positions

The design of this brake has been developed with the view of saving a large percentage of the power which is consumed in operating some types of brake mechanism. The Rockford brake is automatic in its action and is applied only at the top of the stroke. The brake is not applied at any other point

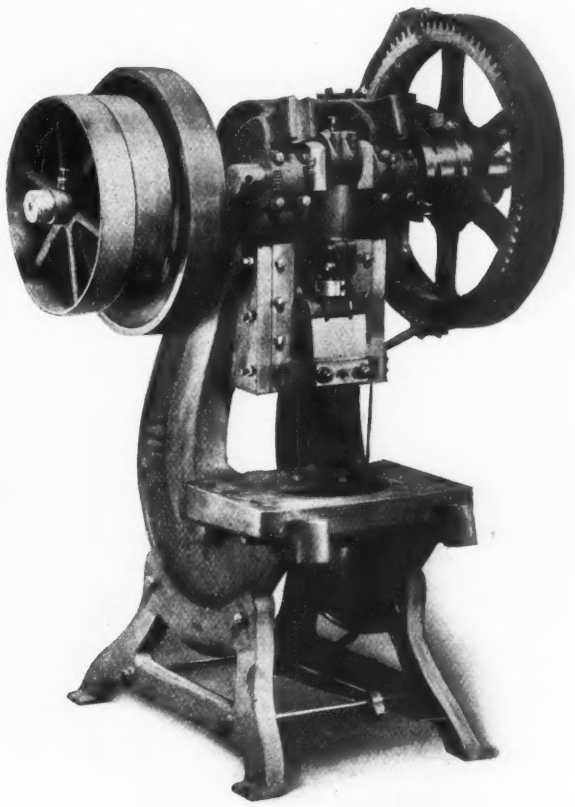


Fig. 2. Rockford High-duty Press equipped with Automatic Brake

during the shaft cycle so that friction losses are reduced to a minimum, only a sufficient amount of resistance being applied to stop the machine at the top of the stroke. The saving of power effected by this device in shops where a large number of presses are in operation will be appreciated.

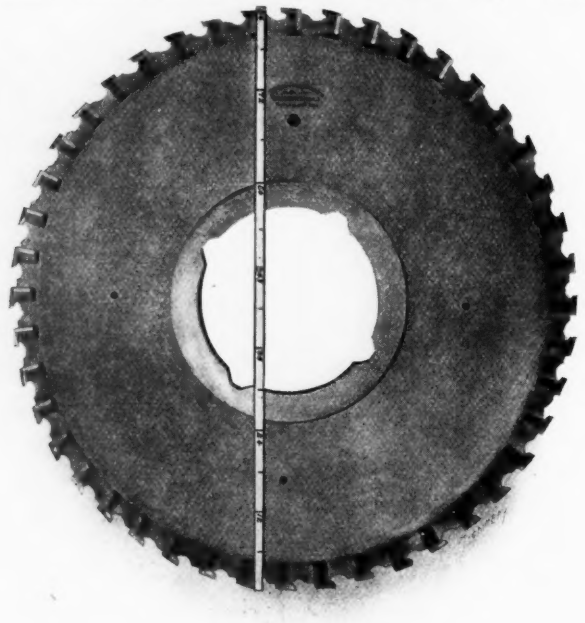
The action of the brake is automatically controlled by the treadle. When the treadle is depressed, the clutch release pawl *A* is drawn down, releasing the clutch pin *B* which is forced forward by a spring into one of the three hardened tool-steel contact points on the flywheel. Just before the clutch pin *B*

is released, and by means of the same pressure on the treadle, the toggle-joint *C*, which holds the brake *D* against a hardened tool-steel projection *E* on the driver *F*, is broken. This releases the brake *D* which is so held until the foot is removed from the treadle. The brake is placed on the right-hand side of the press so that all torsional strain on the shaft is eliminated, and this arrangement gives plenty of room on the left-hand side for the attachment of automatic feed equipment, oiling devices, etc.

HUNTER DUPLEX INSERTED-TOOTH SAW BLADES

The Hunter Saw & Machine Co., 57th and Butler Sts., Pittsburg, Pa., has recently manufactured two of the largest inserted-tooth, metal-cutting saw blades which have ever been placed upon the market. They have been given the trade name of "Hunter duplex," and are made from steel plates 1 inch in thickness and of special analysis to give the best results when subjected to the method of heat treatment used.

The finished saw is 84 inches in diameter, and has a collar on either side which is 26 inches in diameter by 1 inch in



Hunter Duplex Inserted-tooth Metal-cutting Saw Blade

thickness. These collars are riveted to the body of the saw and have four equally spaced keyways milled in them by which the saw blade is driven. Forty-four pockets are milled around the periphery of the saw and roughing and finishing teeth are inserted alternately in them. At the bottom of these pockets, the plate is drilled and tapped to admit a hexagon-headed brass screw which is used in setting the teeth to the proper height. These teeth are made of the best grade of high-speed steel, so that they have an ample cutting capacity, and each tooth is reinforced and rigidly held by a tool-steel wedge. An idea of the size of this saw may be gathered from the fact that the teeth weigh 1¾ pound each, the wedges ¾ pound each, and the saw blade 2000 pounds. These saws were designed for cutting 40-inch ingots, and an idea of their capacity may be gathered from the fact that they are capable of cutting 24-inch ingots in ten minutes. They are driven by a 75-H. P. motor.

NEW MACHINERY AND TOOLS NOTES

Bench Lathe: B. C. Ames Co., Waltham, Mass. A bench lathe equipped with a head that has an extra large spindle. The capacity of the machine is for work up to 2½ inches in diameter.

Pipe Wrench: Erie Stamping & Mfg. Co., Erie, Pa. A convenient form of pipe wrench made from a steel stamping and produced in such a way as to supply the demand for an adjustable pipe wrench at a moderate price.

Hollow Set-screw: Goodwin Hollow Set-Screw Co., Waterbury, Conn. A hollow set-screw designed to be driven in with a suitable wrench, but which has projections on its inner surface that make it possible to use a screw-driver in place of the regular wrench.

Motor-driven Buffing Lathe: Northampton Emery Wheel Co., Leeds, Mass. A motor-driven buffing and polishing lathe. The motor is completely enclosed and bolted to an adjustable bed, which has a vertical adjustment of 4 inches to provide for regulating the belt tension.

Automatic Wire Straightener and Cutter: F. B. Shuster Co., New Haven, Conn. An automatic wire straightener and cutter which has a capacity for lengths up to 67 feet and is said to be the largest machine of its type ever built. It is intended for cutting reinforcements for concrete flooring.

Metal Sawing Machine: Vulcan Engineering Sales Co., Chicago, Ill. A small metal sawing machine in which the saw blade is driven from the periphery by means of steel rolls journaled in removable steel bushings held in the double driving gear. The periphery drive makes a greater portion of the blade available for cutting.

Combination Saw and Rotary Planer: Vulcan Engineering Sales Co., Chicago, Ill. A combination saw and rotary planer mounted on a circular base. This machine is particularly suited to the requirements of structural steel shops. As it combines the functions of two machines in one. it should be a particularly useful equipment.

Horizontal Boring, Drilling and Milling Machine: Lucas Machine Tool Co., Cleveland, Ohio. A new size of precision horizontal boring, drilling and milling machine, known as model No. 31. This machine is similar in its essential details to preceding types built by this company. The new machine is the smallest one of the line.

Adjustable Boring Tool: Armstrong Bros. Tool Co., 313 N. Francisco Ave., Chicago, Ill. An adjustable boring tool in which the bar is made from high-carbon steel tubing. The cutter is held by a drop-forged eye-bolt which has a square yoke at one end to carry the cutter, and a threaded section at the other end for tightening the cutter in the bar.

Open Side Grinding Machine: Detrick & Harvey Machine Co., Baltimore, Md. An open side grinding machine similar in design to the open side type of planers. This machine is intended for grinding such pieces as railroad frogs, switches and crossings, safe and vault parts, and similar classes of work which cannot be handled with cutting tools.

Bench Filing Machine: B. C. Ames Co., Waltham, Mass. A new machine which is a modification of the preceding type manufactured by this company. In the new design, a bench countershaft has been added to the equipment to carry the belt out of the way of the operator, and there is a graduated swivel under the table for securing any desired angular setting.

Planing Machine with Reversing Motor: Woodward & Powell Planer Co., Worcester, Mass. A planing machine driven by a reversing motor which has the Triumph-Monitor system of control. The machine is without overhead gears, belts, belt-shifter or driving pulleys, the motor being coupled to the driving shaft. The controller is fastened to the planer housing.

New Cage-operated Traveling Wall Crane: Cleveland Crane & Engineering Co., Wickliffe, Ohio. A new type of cage-operated electric traveling wall crane which has a capacity of ten tons and consists of two main parts—the bridge proper and the trolley. An important feature of this crane is that the bridge is driven by two motors, which eliminates the use of a through lineshaft and simplifies the design of the machinery.

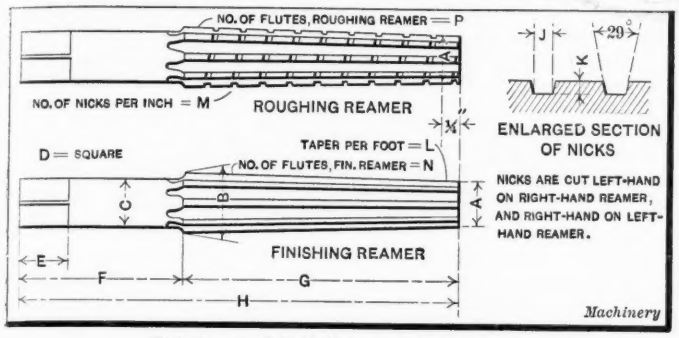
Broaching Machine with Motor Drive: J. N. Lapointe Co., New London, Conn. A motor-driven machine adapted for broaching various shaped holes of small sizes, which has the motor mounted on the same base with it. The switch is conveniently located on the front of the countershaft bracket and the machine has a large ball thrust bearing to receive the pressure from the screw; the countershaft is also equipped with ball bearings.

Geared Double Facing Head: Rochester Boring Machine Co., Rochester, N. Y. A geared double facing head for use on the Rochester horizontal boring machine. The faceplate on the head is geared to run slower than the bar and is made independent of it. The facing head on the outer support is also geared and runs slower than the boring-bar; this head is driven by the extension of the boring-bar through gears at the back of the column.

Automatic Screw Machine: Flanders Mfg. Co., Pontiac, Mich. An automatic screw machine which is the design of Mr. John J. Grant, and has a number of novel and interesting features. This machine has four spindles, all of which are at rest during the non-cutting movements of the machine. These spindles are fitted with the usual type of spring collet, but the stock is fed through without the intervention of feed sleeves or shells. Six changes of feed for the cutting movements are obtained by a simple gear-box, and the cams on the machine never require changing to suit different diameters and lengths of work. There is a constant rate of speed for the return movements, for feeding the stock and for the forward movements of the turret, regardless of the cutting speed. The same countershaft which drives the spindles provides for the constant speed drive, but in the case of the spindles, there are three rates of speed. This number may be doubled by transposing the pulleys on the countershaft and machine.

TAPER REAMERS FOR STANDARD TAPER SOCKETS

Several years ago, some tables were published in MACHINERY giving general dimensions of taper reamers for standard taper sockets, including Morse, Brown & Sharpe, and Jarno tapers. Complete data for the making of these tools have not, however, been published in any form, as far as the writer knows. The


NO. OF FLUTES, ROUGHING REAMER = P
NO. OF NICKS PER INCH = M
ROUGHING REAMER
TAPER PER FOOT = L
D = SQUARE
NO. OF FLUTES, FIN. REAMER = N
FINISHING REAMER
ENLARGED SECTION OF NICKS
NICKS ARE CUT LEFT-HAND ON RIGHT-HAND REAMER, AND RIGHT-HAND ON LEFT-HAND REAMER.
Machinery

Notation used in Tables of Taper Reamers

accompanying tables, therefore, have been prepared with an idea of placing on record all the information that might be required by the toolmaker in making these tools. Special attention is called to the information given for the making of the roughing reamers, which are made smaller in diameter at the small end than the finishing reamers, and which are provided with a groove cut like a thread on the cutting edges, as indicated. The purpose of this groove is to break up the chips. On ordinary right-hand reamers this groove is cut left-hand. The sides of the groove incline at an included angle of 29 degrees. The object of selecting this angle is to make it possible to use a tool having the same included angle as an Acme threading tool for grooving. A tool with inclined sides is preferable to a square tool on account of the greater ease with which the grooves or nicks can be cut. While the shape and exact dimensions for these grooves may seem to be rather unimportant details, yet in manufacturing it is important to so standardize all operations that standard tools can be used. The corners of the grooving tool are slightly rounded to prevent hardening cracks.

In addition to the standard Morse, Brown & Sharpe, and Jarno taper reamers, dimensions of reamers for sockets for the so-called American taper are also included, so that the tables cover practically all reamers used for making taper sockets.

Tables of this kind are of value not only to the toolmaker who may be called upon to make a reamer for a standard taper socket, but also to the user of these tools, who often needs to find out certain dimensions on tools he is about to order, and to the machine designer, who has to keep in mind the tools used in the manufacturing processes. It also enables the designer to choose such tapers for taper locking bolts, etc., as can be reamed with standard taper reamers.

TABLE I. TAPER REAMERS FOR BROWN & SHARPE STANDARD TAPER SOCKETS

No. of Taper	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
A	0.200	0.250	0.312	0.350	0.450	0.500	0.600	0.750	0.900	1.045	1 250	1.500	1.750	2.000	2.250	2.500	2.750	3.000
B	0.252	0.318	0.416	0.444	0.564	0.667	0.803	0.958	1.119	1.346	1.573	1.838	2.114	2.385	2.656	2.927	3.198	3.469
C	7/32	9/32	3/8	13/32	1/2	19/32	23/32	27/32	1	1 7/32	1 7/16	1 11/16	1 15/16	2 1/16	2 1/8	2 1/8	2 1/4	3 1/8
D	5/32	7/32	9/32	5/16	7/16	7/16	17/32	5/8	3/4	29/32	1 1/16	1 1/4	1 7/16	1 19/32	1 25/32	1 31/32	2 5/32	2 11/32
E	1/4	5/16	3/8	7/16	1/2	5/8	5/8	13/16	7/8	1	1 1/16	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8
F	1	1 1/8	1 1/4	1 1/2	2	2 1/8	3 1/8	3 1/4	3 3/8	3 1/8	3 1/4	3 3/8	3 7/8	4	4 1/8	4 1/4	4 1/2	4 1/2
G	1 1/4	1 5/8	2 1/2	2 1/4	2 1/4	4	4 7/8	5	5 1/4	7 1/4	7 1/4	8 1/8	8 1/4	9 1/4	9 1/4	10 1/4	10 1/4	11 1/4
H	2 1/4	3	4 1/4	3 1/4	4 1/4	6 1/2	8	8 1/4	8 1/2	10 1/4	11 1/2	12	12 1/4	13 1/8	14	14 1/8	15 1/4	15 1/4
J	1/32	1/32	1/32	1/32	3/64	3/64	1/16	5/64	5/64	3/32	3/32	7/64	7/64	1/8	1/8	9/64	9/64	9/64
K	0.025	0.025	0.025	0.025	0.025	0.025	1/32	1/32	1/32	2/64	3/64	3/64	7/64	1/16	1/16	1/16	1/16	1/16
L	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	0.5161	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
M	3 1/2	3 1/2	3 1/2	3 1/2	3	3	3	3	3	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2
N	6	6	6	6	6	6	8	8	8	8	8	10	10	10	14	14	14	14
P	4	4	4	4	4	4	5	5	5	6	6	6	6	6	8	8	8	8

Machinery

TABLE II. TAPER REAMERS FOR JARNO STANDARD TAPER SOCKETS

No. of Taper	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900	1.000	1.100	1.200	1.300	1.400	1.500	1.600	1.700	1.800	1.900	2.000
B	0.144	0.269	0.400	0.531	0.659	0.787	0.916	1.044	1.169	1.297	1.422	1.550	1.675	1.800	1.928	2.053	2.181	2.306	2.431	2.556
C	1/8	15/64	8/8	15/32	19/32	11/16	13/16	15/16	1 1/16	1 1/8	1 3/16	1 5/16	1 7/16	1 1/2	1 5/8	1 3/4	1 13/16	1 7/8	1 15/16	2
D	3/32	11/64	9/32	23/64	29/64	33/64	39/64	45/64	51/64	27/32	57/64	63/64	1 5/64	1 1/16	1 7/32	1 11/32	1 23/64	1 13/32	1 29/64	1 1/2
E	3/16	9/32	8/8	1/2	5/8	3/4	7/8	1	1	1 1/16	1 1/16	1 1/8	1 1/16	1 1/4	1 1/8	1 1/8	1 1/4	1 1/4	1 1/4	1 1/8
F	1/8	1 1/4	1 1/2	1 1/4	1 5/16	2 1/2	2 5/16	2 1/2	2 1/4	2 5/16	3 1/16	3 1/8	3 1/2	3 3/8	3 7/16	3 9/16	3 3/4	3 7/8	4	4 1/8
G	1/8	1 3/8	2	2 5/8	3 3/16	3 3/4	4 5/16	4 7/8	5 3/8	5 15/16	6 7/16	7	7 1/2	8	8 9/16	9 1/16	9 5/8	10 1/8	10 5/8	11 1/8
H	1 1/4	2 5/8	3 1/2	4 3/8	5 1/8	5 7/8	6 5/8	7 3/8	8 1/2	8 7/8	9 1/2	10 1/4	10 3/4	11 3/8	12	12 3/8	13 3/8	14	14 5/8	15 1/4
J	1/32	1/32	1/32	3/64	3/64	1/16	1/16	1/32	5/64	3/32	3/32	3/32	7/64	7/64	7/64	7/64	7/64	1/8	1/8	1/8
K	0.025	0.025	0.025	0.025	0.025	1/32	1/32	1/32	1/32	3/64	3/64	3/64	3/64	3/64	3/64	3/64	3/64	1/16	1/16	1/16
L	0.600	0.600	0.600	0.600	0.600	0.600	0.600	0.600	0.600	0 600	0.600	0.600	0.600	0.600	0.600	0.600	0.600	0.600	0.600	0.600
M	3 1/2	3 1/2	3 1/2	3 1/2	3	3	3	3	3	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2	2 1/2
N	6	6	6	6	6	8	8	8	8	8	8	8	10	10	10	10	10	12	12	12
P	4	4	4	4	4	5	5	5	5	6	6	6	6	6	6	6	6	6	6	6

Machinery

TABLE III. TAPER REAMERS FOR MORSE STANDARD TAPER SOCKETS

No. of Taper	0	1	2	3	4	5	6	7
A	0.252	0.369	0.572	0.778	1.020	1.475	2.116	2.750
B	0.369	0.510	0.741	0.979	1.280	1.790	2.559	3.375
C	11/32	15/32	21/32	7/8	1 1/8	1 1/2	2	2 5/8
D	1/4	23/64	1/2	21/32	27/32	1 1/8	1 1/2	1 31/32
E	5/16	1/2	7/8	1 3/16	1	1 1/8	1 5/16	1 1/2
F	1 1/2	1 7/8	2 1/4	2 5/8	3	3 3/8	3 3/4	4 1/8
G	2 1/4	2 13/16	3 3/8	4	5	6	8 1/2	12
H	3 3/4	4 11/16	5 5/8	6 5/8	8	9 3/8	12 1/4	16 1/8
J	1/32	3/64	1/16	5/64	3/32	7/64	1/8	9/64
K	0.025	0.025	1/32	1/32	3/64	3/64	1/16	1/16
L	0.625	0.600	0.602	0.602	0.623	0.630	0.626	0.625
M	3 1/2	3 1/2	3	3	2 1/2	2 1/2	2 1/2	2 1/2
N	6	6	8	8	8	10	14	14
P	4	4	5	5	6	6	8	8

Machinery

TABLE IV. TAPER REAMERS FOR THE AMERICAN TAPER SOCKETS

No. of Taper	1	2	3	4	5
A	0.300	0.416	0.586	0.758	1.033
B	0.435	0.574	0.750	0.943	1.286
C	8/8	1/2	11/16	7/8	1 3/16
D	9/32	8/8	1/2	21/32	7/8
E	8/8	3/8	5/8	1/4	1
F	2	2 7/16	2 5/8	3	3 3/8
G	2 3/4	3 1/16	3 5/8	3 3/4	4 7/8
H	4 3/4	5 1/2	6 1/4	6 3/4	8 1/4
J	1/32	3/64	1/16	5/64	3/32
K	0.025	0.025	1/32	1/32	3/64
L	0.591	0.621	0.543	0.592	0.623
M	3 1/2	3 1/2	3	3	2 1/2
N	6	6	8	8	8
P	4	4	5	5	6

Machinery

STRING DROP-FORGING

BY J. W. JOHNSON*

String-forging is the most economical way of drop-forging small pieces like those shown in Fig. 4. By string-forging is meant the forming of small pieces in a string, without cutting off each piece separately after forging. A section of untrimmed work made by string-forging is shown in Fig. 1. The advantages of handling work by this method are first that it is an extremely rapid operation, in that more forgings can be made per day, and, moreover, there is less liability of the

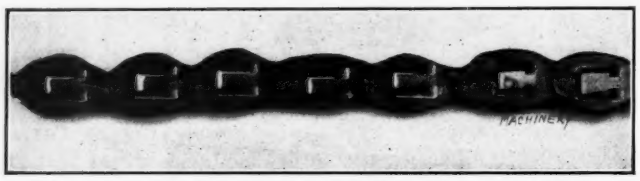


Fig. 1. Section of a String of Sixteen Forgings made in One Heat

drop-forger spoiling work by misplacing it in the dies than when transferring from the breakdown to the face impressions when drop-forging in the ordinary way. Likewise in trimming, the work may be handled more rapidly than is the case when each separate piece must be picked up and laid in the dies separately. While relatively few forgings can be string-forged, still many of the smaller forgings, say under three inches square in size, can be handled successfully in this way. No breakdown can be employed when string-forging is resorted to, for it would be obvious that the time gained by the string-forging method would be lost if it were necessary to shift the string to the breakdown for every forging. From the above it will be gathered that any forging which may be forged without a breakdown, if it does not exceed the approximate limits of three inches square, may be advantageously made by string-forging.

The small yoke for which the dies shown in Fig. 2 were constructed is made of steel. It is approximately ¾ inch wide and 1 inch long, the bosses on the ends being 5/16 inch in diameter. The dies used for this job had faces five by seven inches and the thickness of the blocks was seven inches each. Care should be taken in selecting blocks for string-forging dies for, even though the forgings be very small, the faces must not be too small or the amount of "beating surface" will be insufficient, and thus shorten the life of the dies. As will be seen, the dies are fitted with finishing impressions, and there is also a cut-off at the corner to sever the strings of completed forgings.

For making these forgings, 7/16 inch round steel bars were used. The advisability of using round stock might be questioned, but owing to the large variety of rectangular sizes that would accumulate if other than round stock were employed, it is better to use round stock, even though in some instances an extra blow is required. The bars, of lengths convenient

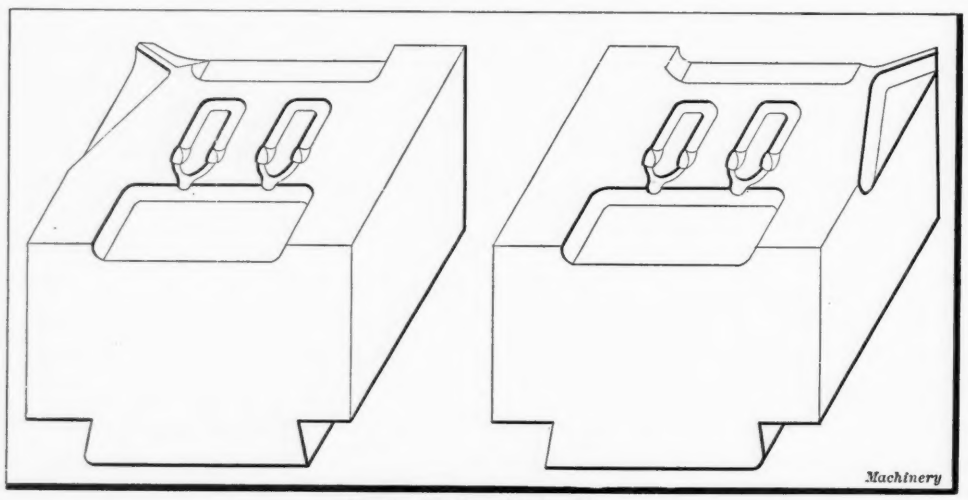


Fig. 2. The Drop-forging Dies

for handling, are heated and the forgings made by striking in the finishing impressions. From two to three blows complete each forging, after which the string is advanced to bring the completed work to the clearance cut at the rear side of the dies, thus permitting another piece to be forged. As many forgings as possible are made in one heat, leaving them all on the string. At the end of the heat the completed string of forgings is cut from the bar and the remainder of the bar is reheated to form another string.

For this work a 500-pound board drop was employed, striking from 30 to 40 blows per minute, and at this rate of speed from 4000 to 4500 completed forgings per day is the output. Work like this is best handled on a board hammer in preference to a steam hammer, and in fact, in the writer's opinion, steam hammers are inferior to board hammers except in the case of very large presses. The constant breakage of parts on a steam hammer is a great source of trouble.

For trimming these forgings from the string, the die shown in Fig. 3 is employed. This trimming die does not differ from the ordinary trimming die except that it is cut away on both ends in order to permit the rest of the string to clear. The tongue which trims the center of the yoke is dovetailed into the die as a separate piece, and in case of breakage, it is only necessary to fit a new center piece. In trimming, the first forging in the string is fitted over the die opening and the

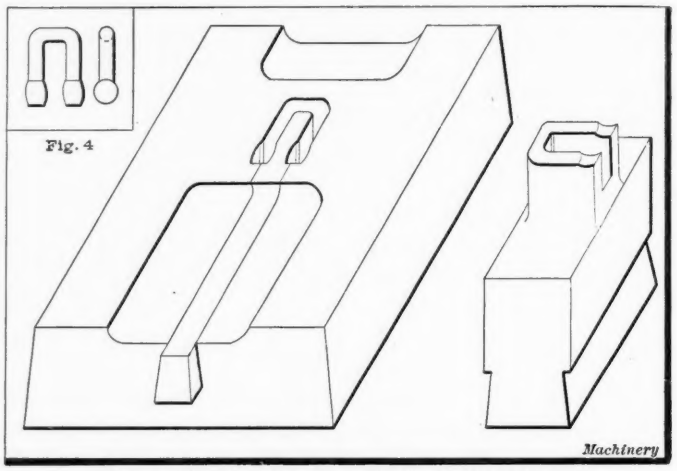


Fig. 3. The Trimming Die Fig. 4. Details of Forging

press tripped, after which the string is advanced until the second forging is in line and so on until all of the forgings are trimmed from the strip.

Another method of string-forging that is often employed when the work is very small is to provide the forging dies with three impressions in a row, so that three forgings are completed at a time. In trimming such work, however, the pieces are treated separately.

* * *

The Cleveland Planer Works uses chrome-nickel steel having a tensile strength of about 140,000 pounds per square inch of section, for the tool-holding studs in clapper-boxes. The ultimate breaking strength and tensile strength of this chrome-nickel steel is about the same, which is a peculiar advantage for tool-holding studs because of the abuse to which they are often subjected. Often a tool will be clamped close to the studs on one side and the nuts on the near studs will be screwed down first. Then when the nuts on the outer side are screwed down, a heavy stress is thrown on the first studs tightened, sufficient oftentimes to stretch or break them. If made of low carbon steel they will be stretched out of lead, thus causing great trouble, but if made of steel having equal elastic and tensile strengths the studs break before stretching much out of lead.

* * *

A man doesn't get behind the times because of age as often as because he just quits trying to keep up.

* Address: 19 Harrington St., Revere, Mass.

EFFICIENT PRODUCTION OF CYLINDRICAL WORK*†

SHOWING HOW TOTAL EFFICIENCY CAN BE INCREASED BY ROUGH LATHE TURNING PREPARATORY TO CYLINDRICAL GRINDING

Turning is one of the oldest of the mechanic arts, and the lathe is one of the oldest metal working machines; but the lathe has been a very inefficient tool until the present time. We now have lathes so designed that they can be made efficient. As a rule, however, we are not using the modern high power lathes as we should, and are losing what they were designed to save, *viz., time;* while we use them as roughing machines, we also use them as finishing machines.

Most cylindrical work must finally be brought to a size within small limits, and be truly cylindrical within still smaller limits; this led mechanics to study the art of refined turning. When this art had reached a high degree of refinement, men discovered that it did not satisfy them, and cylindrical grinding was introduced to give greater refinement than could be obtained with the lathe. At that time, it was the somewhat natural conclusion that the grinding machine should take up the work after the limit of refinement had been reached with the lathe, and the early grinding machines were designed with this object in view. Later, however, it was shown that ground cylindrical work could be produced at a cost no greater than the turning alone, by simply using the lathe to remove the larger portion of the metal and not at all as a means of refinement. The entire responsibility for refinement of the work was then transferred to the grinding machine.

While some understand this method and are using it to produce cylindrical work efficiently, the great majority are still under the spell of tradition, and are turning what they call "good work"—work that shows care and skill on the part of the operator and accuracy in the lathe. Such care in producing turned work is even more senseless today than the old-time practice of shaping acorns on screw heads, and putting cast-iron eagles on the tops of machine tools. In the former case, the grinding machine removes all trace of the lathe's accuracy and the operator's skill in a moment of time, while the latter remained for years to gratify the taste of those who had an eye for such artistic embellishment. The developments of the last few years have brought us face to face with the fact that, except in rare cases, efficiency in the production of cylindrical work means the use of the lathe as a roughing tool only, and the adoption of the modern grinding machine for refinement.

Most lathe operators and foremen seem to understand roughing to be simply turning work a few thousandths over the finish size. In reality, this is not roughing at all, but simply turning to a certain degree of refinement. It is difficult to secure roughed work from lathe operators, *i. e.*, work that is not in any sense refined. Tradition causes most operators to consume much more time than would be necessary if the work were merely roughed; sometimes they understand roughing, but confuse it with a certain degree of refinement. Roughing is not refinement of any degree, and refinement does not necessarily mean perfection. There are many degrees of refinement, but never degrees of accuracy or perfection. Accuracy and perfection are final and fixed; they have no limits.

Those who would produce cylindrical work efficiently must recognize the fact that different cases require different degrees of refinement; but whether the work requires a very low degree of refinement or a degree closely approaching accuracy, the lathe work to be efficient, should be the same, *viz.* as *rough* and as *cheap* as it is possible to make it. The lathe of today should only be a roughing tool, and the grinding machine a refining tool only—not a perfecting tool. Some grinding machines may produce greater refinement than others, but none can produce exact and perfect cylinders. While it is true that many mechanics look upon a high degree of refinement as accuracy, and speak of it as such, it is evident that this is not the case. When these facts are generally recognized, there will be greater efficiency in the production of cylindrical work. Because these facts about roughing and refining are not well understood, and because men do not combine the lathe and grinding machine in a well defined and efficient manner, the machine industry and railroads are losing large sums of money every year.

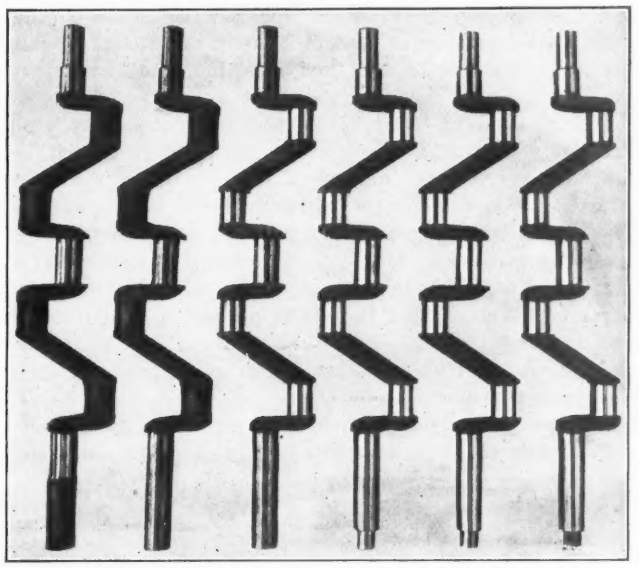


Fig. 2. Crankshaft requiring practically No Lathe Work in finishing

This loss is due to the fact that we turn closer than about 1/32 inch above the finished size. The word *about* is used because we lose by turning carefully. To require lathe work to be turned to thousandths today is like burning money for the fun of it. We are losing by allowing workmen to use any but the coarsest feeds that it is possible to use in each case. In some cases, it is even advisable to use the screw cutting gears. Feeds as coarse as four to the inch should be used in some cases, and feeds of six, eight and ten to the inch should be quite common. When the work is too frail to allow such coarse feeds to be taken with one cut, a second, or even three cuts should be made at a faster cutting speed; for, while it is true that very coarse and imperfect turning will require longer to grind than close, careful turning, the combination of coarse, cheap turning with grinding will produce cylindrical work

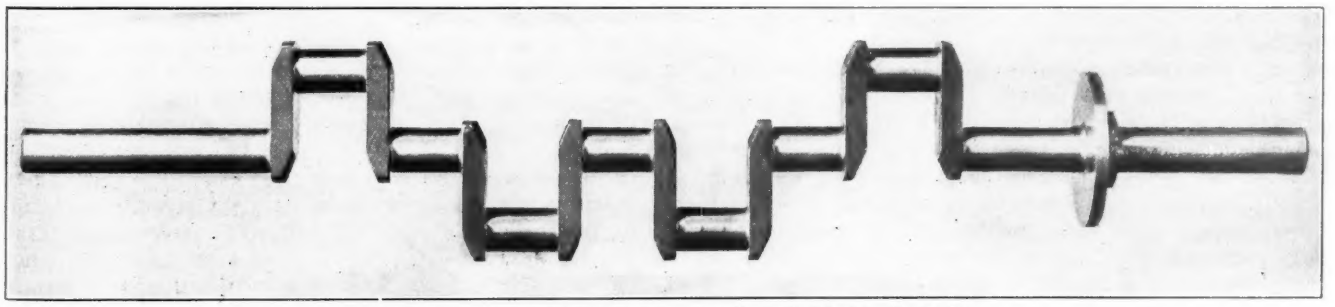


Fig. 1. A Crankshaft that is almost entirely finished in the Lathe

*Abstract of paper by Mr. C. H. Norton, of the Norton Grinder Co., Worcester, Mass., to be presented before the American Society of Mechanical Engineers, December, 1912.

†For additional information on grinding, see "Commercial Grinding," by F. B. Jacobs, in the October issue of MACHINERY, and other articles there referred to.

more efficiently. The modern grinding machine will remove metal most efficiently when that metal is in the form of coarse screw threads. High ridges do not increase the cost of production, and we lose money when workmen are allowed to caliper cylindrical work on the tops of the ridges, as nearly all of them do. This accounts for the misunderstanding about coarse turning and the allowance for grinding. Calipering on the tops of the ridges makes it necessary to turn with a relatively fine feed to enable clean grinding to be done. To avoid this, some workmen use a broad nose tool with the coarse feed, which necessitates the use of a slower cutting speed, because more metal is removed than with a pointed or grooved cutting tool. Ridges left by a more pointed tool do not increase the cost of producing that work, but decrease it.

We lose money by allowing workmen to measure roughed work elsewhere than at the end. Hours are wasted in calipering at several points and then resetting, and again turning the portions that have been put out by spring or tool wear, to secure straight work. It is very simple to feed a slight distance at the end of the work by hand, where the calipering can be done correctly, however coarse the power feed may be later on, or however high the ridges. The fact is overlooked that the modern grinding machine was designed to do all of the straightening and all of the sizing, regardless of what the errors of roughing may be. It is also forgotten, or has never been known, that the art of producing cylindrical work has progressed beyond that stage where it was necessary for the lathe to do its best before the grinding machine assumed the work of refinement.

The modern grinding machine is actually a correcting machine. The roughing can be rough, and roughness does not mean an approximate refinement. It is easy to figure the saving in time of turning a piece of work 6 inches in diameter by 6 feet long, when the last cut before grinding is made with a feed of six per inch, instead of thirty-two per inch, which is common. When it is considered that the grinding machine will grind this six per inch work to the finish size, in less time than is required to file thirty-two per inch work, we see the great possibilities for reducing the cost of producing work with the lathe, if combined with a modern grinding machine. In some cases money is lost by roughing at all in the lathe. Efficient production of cylindrical work is usually accomplished by first roughing in the lathe, but there are cases when the difference in favor of grinding without any roughing in the lathe is very great. The most important study for those who would secure efficient production of cylindrical work is the roughing of that work. It is here that we find the greatest possibilities for saving. If all would make a careful study of the roughing preparatory to grinding, instead of trying to improve upon the methods of grinding advocated by grinding machine makers, the result would be a more efficient production of cylindrical work and a clearer view of the real reasons why the grinding machine maker advocates certain methods. The reason why the modern heavy grinding machine was introduced would also be better understood.

At a works where large numbers of cylindrical pieces 1⅛ inch in diameter and about 10 to 11 inches long are manufactured, five minutes was required to turn about 1/16 inch from the diameter of each piece with a high-speed steel tool, the work being revolved as rapidly as the tool would stand. The plan was to turn close to the finish diameter, and care was taken to secure work that was smooth, straight, and round, so that time might be saved when grinding. They considered the grinding expensive and thought that this expense must necessarily be added to the cost of turning. The grinding in this case took one minute. The total time for producing these pieces was six minutes. A change was made in the shape of the tool point, and the size limit for turning, increased. The traverse feed was also increased, the cutting speed remaining unchanged. Each piece of work was now turned in one minute, while the grinding time was doubled so that it took two minutes. The saving of time resulting from the change was three minutes, or one-half of the original time.

Some idea of the time lost by allowing lathe work to be turned straight, smooth, and close to size, before grinding, may be obtained from the following illustration of actual work on some forgings about 4 feet 6 inches long. The turned portion had to be brought to a finish of 2 inches plus or minus 0.0005 inch in diameter, and 3 feet long. The lathe operator turned these pieces in the same manner that the majority of operators are now turning such work, *viz.*, as such work was turned before grinding machines were introduced, except that 0.010 inch was left on the diameter for grinding. The turning required two cuts, as there was more than ⅛ inch to remove and the work was somewhat frail, as well as irregular. The first cut was considered a very coarse heavy cut by the workman. The second was like the last cut in the majority of shops, *viz.*, it gave what the lathe men and most foremen call "a good job." When ready for grinding, the time consumed by turning was 25½ minutes. This appears to be too slow, but the forging was so slim that it would allow little, if any, increase in each roughing cut, and the lathe was an old-time low-power, frail machine. The grinding time on this job was three minutes, making a total of 28½ minutes.

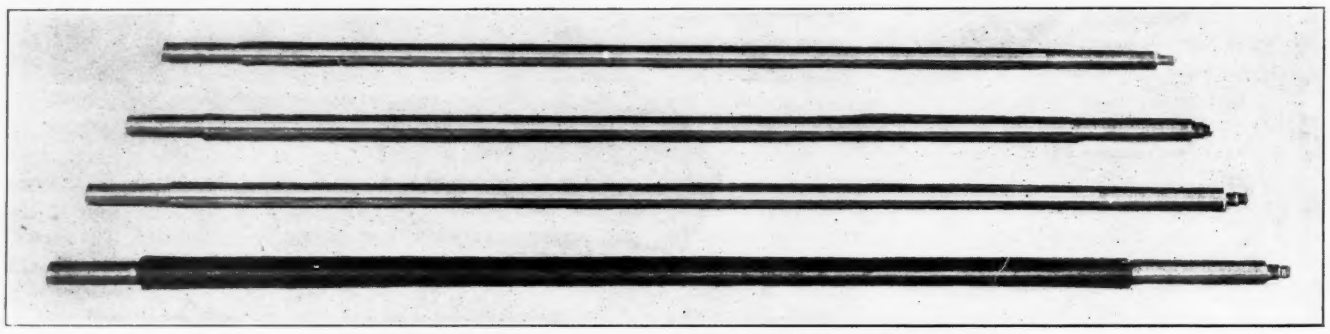


Fig. 8. Work Too Thin to be turned efficiently—finished entirely by grinding

Now note what was accomplished with the same low-power lathe and the same work, when tradition was ignored and the work made ready for grinding in the proper way. Two roughing cuts were taken, because the lathe was not powerful and the work was frail. The feed was ten per inch, cutting deep grooves; the time complete ready for grinding was nine minutes. The work was not straight, and was what many lathe men would style "a very poor job." The grinding time occupied to bring the work to exact limits was nine minutes, or three times longer than with the more careful turning, and the total time eighteen minutes, a saving of 10½ minutes on each forging. An attempt to rough this work with one cut instead of two resulted in a loss of two minutes. A modern, high-power lathe would have carried the same feed and depth of cut at a higher cutting speed, with a still further reduction of time. This shows us what may be accomplished with our weak low-power lathes. To install high-power lathes and continue to turn just as smoothly and accurately as of old, simply allowing a few thousandths for grinding, would seem the height of wastefulness. Whether high-power lathes, or old low-power lathes are used, mechanical industries are losing an enormous sum each year because of the lack of understanding of the efficient production of cylindrical work —the proper combination, in each individual case, of rough turning and grinding.

Some idea of what we are losing by not wearing our "thinking cap" is shown by the following: Some plain shafts, 1 5/16 inch in diameter and 62 inches long, were to be made

to ordinary limits of size and finish. Tests were made to determine whether it was better to turn these first, or to grind direct from the rough bars. The turning required six minutes ready for finish grinding, while to grind off the same amount as was turned required nine minutes. A number of mechanics, without thinking, pronounced it cheaper to turn these shafts first. But in this case, after turning in six minutes, each shaft required straightening before grinding; this consumed ten minutes on each shaft, totaling sixteen minutes. When the roughing was done by grinding instead of turning, no straightening was necessary, and the roughing cut was taken in nine minutes. In this case, therefore, the turning was actually lost. There may be similar cases where the shafts will require some little straightening, even if roughed by grinding, so that each case should be investigated, instead of making a rule that all must or must not be turned first. Usually, however, no straightening is necessary when roughing is done by grinding.

Money is being lost because the majority of designers have not kept pace with the development along these lines. A

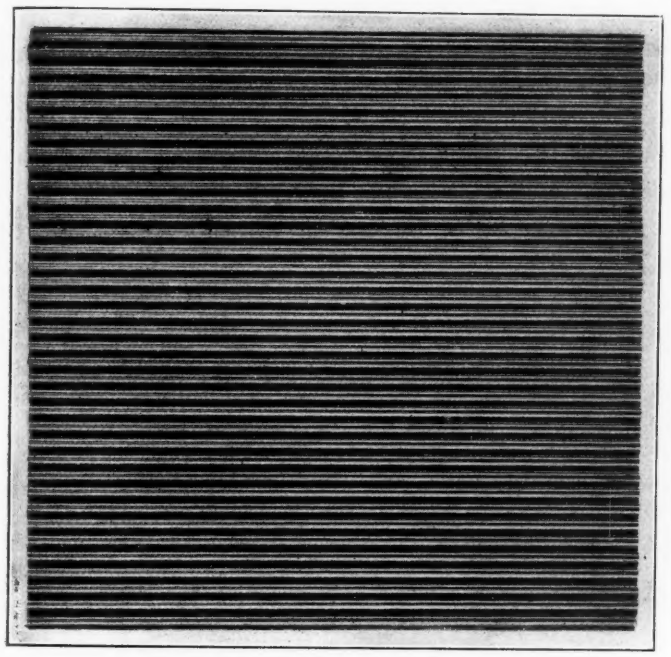


Fig. 4. Thirty-seven Slim Shafts ground direct from Rough

well-known runabout motor car has a crankshaft, which, if made about one inch longer over-all, could have been produced for 50 cents less on each crank. When it is considered that about 30,000 of these cranks have been made, representing a possible saving of $15,000, we see the importance of the combination of lathe and grinding work.

Fig. 1 shows a design of crankshaft that is expensive to machine, as it requires careful finished lathe work. It will be seen that this shaft has a flange that must be finished complete by the lathe. Aside from the flange, the design necessitates lathe finishing of the majority of the work. Grinding is a small part of the whole.

Fig. 2 shows a design that requires no lathe work whatever, there being clearance for the sides of the grinding wheel at all points. The illustration shows the six operations to complete the shaft after cutting off the ends and centering. These shafts are finished to the usual limits, direct from the drop-forging, by grinding. The net labor cost for cutting off ends, centering, machining complete with one keyway, and cutting the thread, so that the shaft is ready for the automobile, is 55 cents. The cost for grinding wheel is 2½ cents for each shaft, and the cost for the diamond to true and shape the wheel is 2 cents.

Another feature affecting the cost of production is the matter of shoulders. This is overlooked by many designers, and practically all draftsmen, who show sharp corners at the junction with the cylindrical portion. It is so easy to draw two sharp lines that cross each other and form a sharp corner. The fact that it costs less to provide room for the shoulder fillet on the other member than to make a sharp corner in the cylindrical member is lost sight of. This, no doubt, is the result of the experience of the past, when there were no powerful grinding machines to locate and form such shoulders cheaper than the lathe could. Shoulders made with the grinding wheel require a slight fillet.

When numbers of duplicate pieces are to be produced and a small fillet is allowed, not only can the cylindrical portion be roughed with the lathe and not at all refined, but the shoulders can also be roughed, because the grinding machine, when required, is provided with a locating bar. By the use of this bar, the exact location of all shoulders can be secured by grinding, without necessitating any measuring. At the same time, the cylindrical portion can be ground with the same grinding wheel. The roughing in the lathe can be done with the same tool that roughs the cylindrical portion because the lathe, in this case, is not required to give the shoulder any particular shape. When it is found best to locate and finish shoulders with the lathe, because there is no locating bar for the grinding machine, it should not be necessary to neck in at the shoulders for grinding. This is an old and out-of-date notion, for, with a shoulder cut sharp by the lathe tool, the grinding does not materially change the corner. A more efficient method, when no locating bar is at hand, is to rough the work in the lathe, leaving the shoulders about 1/32 inch long and of whatever angle the rough-turning tool may form. Next grind the cylindrical portion and, at the same time, cut out the angle at the shoulder with the grinding wheel. The work should then go to a lathe where a more skillful operator can locate the shoulders accurately; if a sharp corner is really necessary, it can then be made.

Fig. 3 shows work that is so slim that turning the main portion is out of the question, if it is to be produced efficiently. The main or center portion should be ground direct without turning. Fig. 4 shows thirty-seven slim shafts ground direct from the black stock. To turn them first would be a waste of time. They were 30 inches long by 11/16 inch in diameter in the rough. They were ground to 0.625 inch plus or minus 0.0005 inch; the work was handled twice and ground complete in seventeen minutes for each piece. The stock was tool steel. A lot of sixty countershafts of 35-point carbon steel, finish size 2 3/16 inches plus or minus 0.0005 inch by 66 inches long, were turned eight pitch, leaving about 1/32 inch for grinding. They were ground complete in thirty-five minutes each. The number of cubic inches of steel ground off was 278; 20.7 cubic inches of steel being removed for every cubic inch of wheel wear. The total wheel cost for sixty shafts was 38 cents, and the total cost for power, 35 cents. The type of wheel used was 24-combination grade L, alundum. The radial depth of cut when roughing was 0.001 inch and when finishing 0.0005 inch. The surface speed of work when roughing was 42 feet per minute, and finishing 35 feet per minute. The table traverse for roughing was 11¼ feet per minute and for finishing 10 feet per minute.

To produce cylindrical work efficiently we must make a study of everything that affects the problem in each individual case, instead of following tradition, which is costing us thousands of dollars every year. Lathe builders are offering some very efficient roughing lathes, but are we roughing with them? In most cases, we are not. The real roughing lathe needs a good system of multiple steadyrests to enable it to take rapid and deep coarse cuts. Will someone come forward with such a system of steadyrests? Instead of our lathe departments and grinding departments being separate, there should be one department for cylindrical work under one foreman. This would check the tendency of the lathe department to treat their work as a finished product, and the tendency of the grinding department to insist upon close careful turning in order to make a better showing on the grinding time, regardless of the real cost of production. There is much yet to be learned about the preparation of cylindrical work for grinding, as no two pieces of work require the same lathe treatment. There is also a great need for thinking men as foremen and operators. Such men can effect great savings by working out the best combination of turning and grinding for each class of cylindrical work.

NEW SHOP OF THE CINCINNATI GEAR CO.

The Cincinnati Gear Co. is now located in its new shop at 1825–1833 Reading Road, Cincinnati, Ohio. A good idea of the modern construction and equipment of this shop may be obtained from reference to Figs. 1, 2, and 3. The building has been provided with an exceptional window area which affords an ample amount of daylight, so that all machines may be operated without artificial illumination.

This company started in business in a small way, two years ago, and has grown rapidly. A specialty is made of rawhide and bevel gears, and an idea of the quantity of work turned out may be gathered from the fact that fifteen bevel gear machines are kept in operation all the time. All kinds of bevel gears—including those of fractional pitch—are cut without the use of form cutters or templets, planer generators being used exclusively.

Fig. 1. New Shop of the Cincinnati Gear Co., Cincinnati, O.

* * *

MACHINE TOOL EXHIBIT AT NATIONAL AUTOMOBILE SHOW

A new feature of much interest to the machine tool building industry will be added to the thirteenth National Automobile Show, to be held in Madison Square Garden and Grand Central Palace, New York, January 11 to 25. A machine tool exhibit is planned for tne Part 1I period, or second week, beginning January 20, which is devoted exclusively to commercial vehicles. The proposed exhibit has received the approval of President E. P. Bullard, Jr., of the National Machine Tool Builders' Association and of its executive committee.

The members of the Society of Automobile Engineers, many of whom will attend the show for the entire two weeks, have expressed themselves as being in favor of a display of machine tools and accessories used largely in the manufacture of motor cars. The time is ideal for the machine tool builders supplying the automobile trade to meet the men personally who are vitally interested in their product. Automobile factories throughout the country are constantly increasing their machine tool equipment, and their engineers will welcome the opportunity to see the latest developments.

The exhibit of cars in the second week of the show has not attracted the general public in large crowds, but chiefly business men, manufacturers and mechanical engineers concerned with the problems of transportation and in the development of motor trucks and delivery cars. The educational value of the proposed exhibit of machine tools to these classes is of no little importance. The intention of the management is to make the display of machine tools an annual feature of future shows.

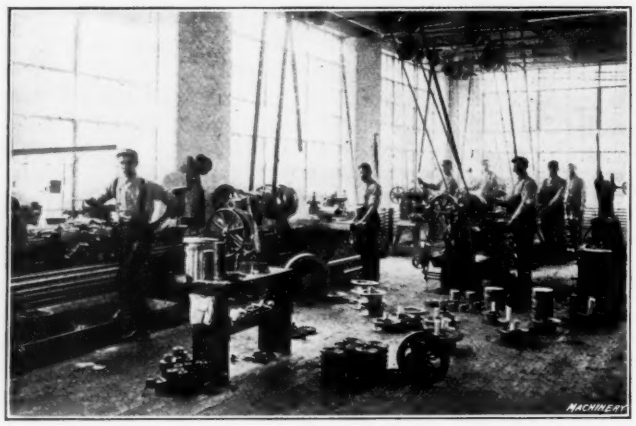


Fig. 2. Corner of the Lathe Shop showing Liberal Window Space

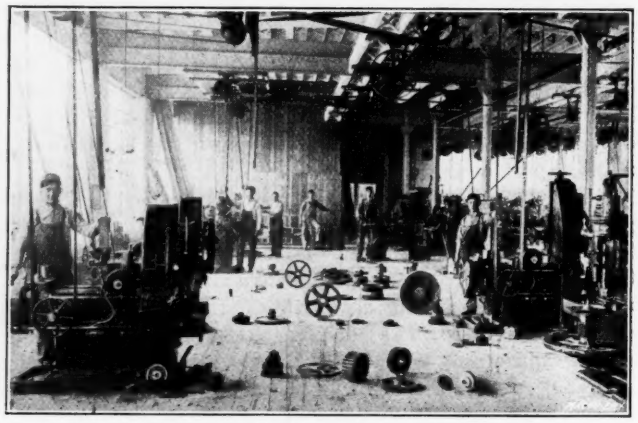


Fig. 3. The Spur Gear Shop and Some Samples of Work

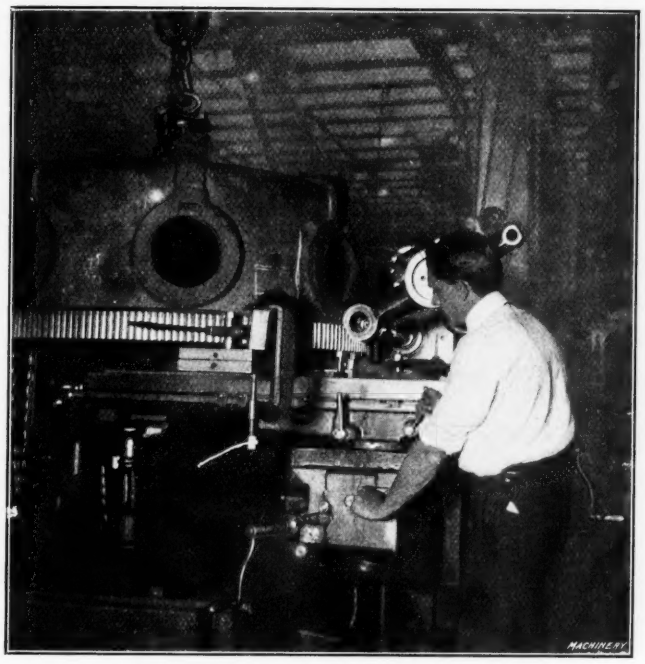
* * *

Tests made at Watertown Arsenal some time ago, which strikingly demonstrated the truth of Wöhler's law that the endurance of steel decreases rapidly with increases of stress above a certain percentage of the elastic limit, were cited in an article "The Factor of Safety" appearing in the first number of *The Travelers Standard*. Wöhler, a German railway engineer who was the first to scientifically investigate factors of safety, had observed that car axles often break after having run a certain number of miles although when new their strength was several times that required to carry the load, and from this fact was led to investigate the phenomena of fatigue of metals. The Watertown tests were made on steel specimens having the following characteristics: Carbon content, 0.55 per cent; ultimate tensile strength, 111,200 pounds per square inch; elongation, 12 per cent; reduction of area, 33 per cent; elastic limit 59,000 pounds per square inch. Under repeated alternate extension and compression stresses a specimen under maximum stress of 30,000 pounds per square inch withstood 76,326,240 repetitions without breaking; under 35,000 pounds a specimen broke at 900,720 repetitions; under 40,000 pounds, at 455,000; under 45,000 pounds, at 166,-240; under 50,000 pounds, at 93,160; and under 60,000 pounds, at 12,400.

AN UNUSUAL GEAR CUTTING JOB

An unusual job of gear cutting was recently performed in the shop of William Ruwell, 719-21 Noble St., Philadelphia, Pa., and is believed to be one of the largest pieces of gear cutting which has ever been done on a No. 4 milling machine. The work consisted of an iron casting 56 inches in diameter which had a four pitch gear cut on its outside circumference. The gear face was 3 inches in width, the total width of the casting 24 inches, and its weight about 2680 pounds.

This gear was cut on a No. 4 Cincinnati universal high-power milling machine. The casting was supported by a ball



An Unusual Job for a No. 4 Milling Machine

bearing placed in the center at the top and a triple rope and block tackle was used to raise it into position. The weight of the casting was counterbalanced, the counterweight being located at a point where it could not interfere with the work. This arrangement worked so well that it was estimated that the casting was raised by a pull not exceeding ten pounds.

The regular universal dividing head was moved to the extreme left end of the milling machine table; the spindle of the head was then placed in a vertical position and an arbor made to fit the hole in the casting. The other end of the arbor was located in the dividing head. The casting was now lowered onto this arbor and a stocking cut taken all the way around. The casting was then examined to see that this stocking cut gave accurate results, after which the worm-wheel of the dividing head was thrown out, and with the casting still mounted on the dividing head, a pawl was attached to the table of the milling machine. This pawl was now used for indexing the work, the C-clamp shown in the illustration being used to hold the casting securely in position. Although this work is considerably beyond the range usually covered by a No. 4 milling machine, the job was turned out with satisfactory results.

* * *

IMPORTANT PATENT DECISION AFFECTING TRUST AGREEMENTS

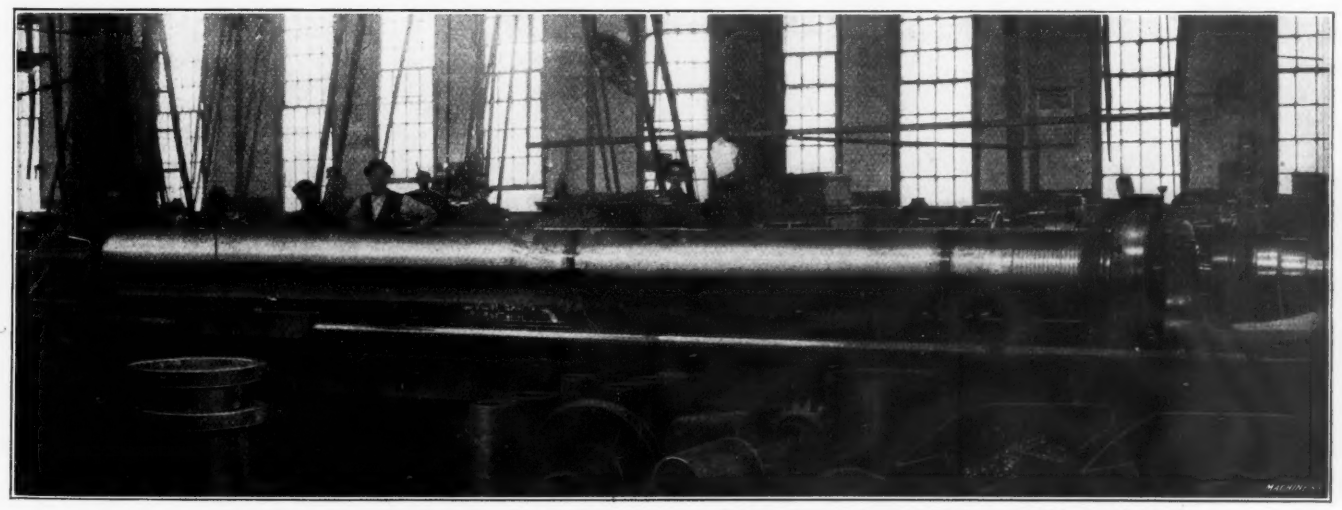
The United States Supreme Court, on November 18, affirmed the opinion of the Federal District Court of Maryland that the Standard Sanitary Mfg. Co., and forty-nine other defendants, constituting the so-called "bath-tub trust" are not, under the patent laws, warranted in making the license agreement under which they have been doing business. Under this license agreement, the various manufacturers of bath-tubs were allowed to use a patented device in their manufacturing processes, but only on condition that they abided by an attached price list, would not sell to jobbers who bought from independents, would not sell in a certain territory, and would not sell "seconds." The court held that it is illegal for the manufacturer of a patented article to fix the price at which articles manufactured by it must be sold at retail, and thus laid down the broad principle that there can be no monopoly in the unpatented product of a patented machine without the violation of the anti-trust law. Justice McKenna delivered this as the unanimous opinion of the court.

The Supreme Court in this decision refuses to extend the doctrine of the Dick mimeograph case to the unpatented product of a patented machine. The defendants in the bath-tub case owning patents on machines used in the manufacture of enameled ware attempted to fix prices and destroy competition in an unpatented product, but their conduct was held to be illegal. This decision, together with that of the Dick mimeograph case, in which it was held that the purchaser of a patented device could be compelled to buy from the patentee all the supplies used on that particular machine, are probably the two most important decisions in patent cases in a number of years.

* * *

HEAVY THIRTY-SIX-INCH LATHE JOB IN A PITTSBURG STEEL PLANT

An exceptional lathe operation which was recently performed in one of the large steel plants in the Pittsburg district is illustrated herewith. The work is a 3½ per cent nickel steel shaft, which was turned from a forging 25 feet



Turning an exceptionally Large Nickel Steel Shaft on a 36-inch Boye & Emmes Triple-geared Engine Lathe

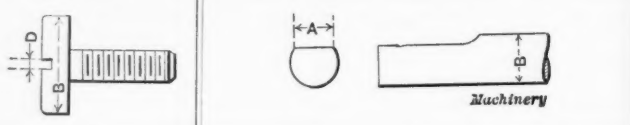
5 inches in length by 22 inches in diameter, which weighed 33,000 pounds. When finished, the maximum diameter was 20 inches and the weight 28,000 pounds. The engine lathe used for this purpose is of the regular 36-inch triple-geared type manufactured by the Boye & Emmes Machine Tool Co., successors to Schumacher & Boye, Cincinnati, Ohio. The ability to deal with such a job, which is necessarily a most severe test, certainly speaks well for the capacity of the lathe on which the work was performed.

SLOTS IN SCREW HEADS—WIDTH OF FLAT ON SHANKS OF TOOLS

For ordinary fillister-head screws, where the diameter of the head is made in proportion to the diameter of the body of the screw, the width of the screw slot ought to be made according to the standard approved by the American Society of Mechanical Engineers in May, 1907. According to this standard, the width of the slot is figured from the formula $D = 0.173A + 0.015$ inch, in which D equals the width of the slot for the screw-driver and A equals the diameter of the body of the screw itself. When the screw heads are made especially large in proportion to the body of the screw, however, as shown in the illustration at the top of the accompanying table, this formula is not adaptable, as the screw slots would be entirely too narrow for the size of the head, and, in that case, it is better to base the width of the slot for the screw-driver on the diameter of the head rather than on the body diameter of the screw. In this case the width of the screw-driver slot is calculated from the formula $D = B \times 0.090$, in which D equals the width of the screw-driver slot and B the diameter of the head of the screw. This formula gives good proportions for average conditions, although, of course, judgment must be used in drawing the line between the conditions when the regular A. S. M. E. formula ought to be used and when the head is large enough to call for the use of the present formula. A table is given in which the width of the screw-driver slot is calculated for different diameters of head according to this formula.

TABLE OF SCREW-DRIVER SLOTS

TABLE OF FLATS FOR SET-SCREW ON SHANKS OF TOOLS



B	D	B	A	B	A
3/16	0.017	1/8	0.047	1 5/16	0.492
7/32	0.019	5/32	0.058	1 3/8	0.515
1/4	0.022	3/16	0.070	1 7/16	0.539
9/32	0.025	7/32	0.082	1 1/2	0.562
5/16	0.028	1/4	0.094	1 9/16	0.586
11/32	0.031	9/32	0.105	1 5/8	0.609
3/8	0.034	5/16	0.117	1 11/16	0.633
13/32	0.039	11/32	0.129	1 3/4	0.656
1/2	0.045	3/8	0.140	1 13/16	0.679
9/16	0.050	13/32	0.152	1 7/8	0.703
5/8	0.056	7/16	0.164	1 15/16	0.726
11/16	0.062	15/32	0.176	2	0.750
3/4	0.067	1/2	0.187	2 1/16	0.773
13/16	0.073	9/16	0.211	2 1/8	0.797
7/8	0.079	5/8	0.234	2 3/16	0.820
15/16	0.084	11/16	0.258	2 1/4	0.844
1	0.090	3/4	0.281	2 5/16	0.867
1 1/16	0.095	13/16	0.304	2 3/8	0.890
1 1/8	0.101	7/8	0.328	2 7/16	0.914
1 3/16	0.107	15/16	0.351	2 1/2	0.937
1 1/4	0.112	1	0.375	2 5/8	0.984
1 5/16	0.118	1 1/16	0.398	2 3/4	1.031
1 3/8	0.124	1 1/8	0.422	2 7/8	1.078
1 7/16	0.129	1 3/16	0.445	3	1.125
1 1/2	0.135	1 1/4	0.469	...	.....

The width of the flat for set-screws on round shanks of tools may not seem to be of great importance, but, nevertheless, it is advisable to have a standard for this. The accompanying table gives, therefore, the width of the flat A for a number of different diameters B figured from the formula $A = \frac{7}{8} B$. If the flat is milled to this width, the appearance of the tool shanks will be satisfactory, and by using a standard, uniformity is assured.

Tools with a square milled on the shanks often present a bad looking appearance by having sharp corners. This often produces burrs on the square itself, which prevent the tools from entering the socket or wrench in conjunction witn which they are used, and—what is still worse—is often the cause of bruised and cut hands. A well-proportioned square having a good round corner is obtained if the width across the flats is made ¾ times the diameter of the shank. A.

LAUNCHING OF THE NEW YORK

The ninth U. S. dreadnaught *New York* was launched at the Brooklyn Navy Yard October 30. This battleship is a sister ship to the *Texas*, building at Newport News by the Newport News Shipbuilding & Drydock Co., and is the largest yet launched. Her keel was laid in September, 1911, and when launched the construction was about sixty per cent completed; the hull at launching weighed over 9000 tons. About 25,000 pounds of special grease was used to lubricate the launching ways. These ways consist of two wooden tracks, each about four feet wide and thirty feet apart upon which the vessel rests at launching, being supported in a cradle or sliding ways built to conform to the hull. The spectacular "sawing off" of the sliding ways to release the vessel was made obsolete by a double trigger device, located in the launching ways amidship, and operated by two hydraulic plungers. The vessel had been wedged up onto the launching ways and was held only by the triggers when the signal was given. The turn of a valve released the liquid in the cylinders, and the weight of the vessel pressed the triggers down out of the way, thus freeing her to slide into the water. The mechanism worked perfectly and will be used hereafter; it insures the safety of the men, and enables the time of release to be fixed to the fraction of a minute.

The *New York* is the largest and most formidable battleship in the world, the mean displacement being 27,000 tons; the length on water line, 565 feet; breadth at water line, 95 feet; mean drafts, 28 feet 6 inches. The propelling machinery is triple expansion reciprocating engines of 28,100 H. P. driving two propellers. The main battery comprises ten fourteen-inch rifles and four submerged twenty-one-inch torpedo tubes; and the secondary battery, twenty-one five-inch rapid fire guns, and smaller pieces. The cost of the fourteen-inch gun and mount is $62,000 for the gun and $50,000 for the mount. The life of a gun before relining is necessary is 225 rounds. The range at fifteen degrees elevation is over twelve miles, and the penetration of face-hardened armor at six miles is sixteen inches. The cost of a round of ammunition is $600. The total cost of the vessel, hull and machinery exclusive of armor and guns is about $6,000,000.

* * *

PERSONALS

Robert Cary has resigned his connection with the Gisholt Machine Co., Warren, Pa., and taken a position as superintendent of the J. N. Lapointe Co., New London, Conn.

H. S. Kartscher has left the designing department of the Pratt & Whitney Co., Hartford, Conn., to take the position of chief draftsman of the Rivett Lathe & Grinder Co., Brighton, Boston, Mass.

M. O. Frenier, mechanical engineer, formerly with the engineering department of the Knox Automobile Co. of Springfield, Mass., has opened an engineering office at 168 Bridge St., Springfield, Mass.

J. E. Brennan, who for several years held the position of assistant superintendent of the Remington Arms–Union Metallic Cartridge Co., at the works in Ilion, N. Y., has been appointed superintendent of the works.

A. J. Jones, formerly with the Lodge & Shipley Machine Tool Co., Cincinnati, Ohio, has been made secretary and manager of the Acme Machine Tool Co., of Cincinnati, manufacturer of turret lathes and screw machines.

Walter G. Lamont, late with Elliott & Fisher Co., Harrisburg, Pa., manufacturer of billing machines, has taken the position of mechanical engineer with the Simplex Non-Refillable Seal & Stopper Co., at Baltimore, Md.

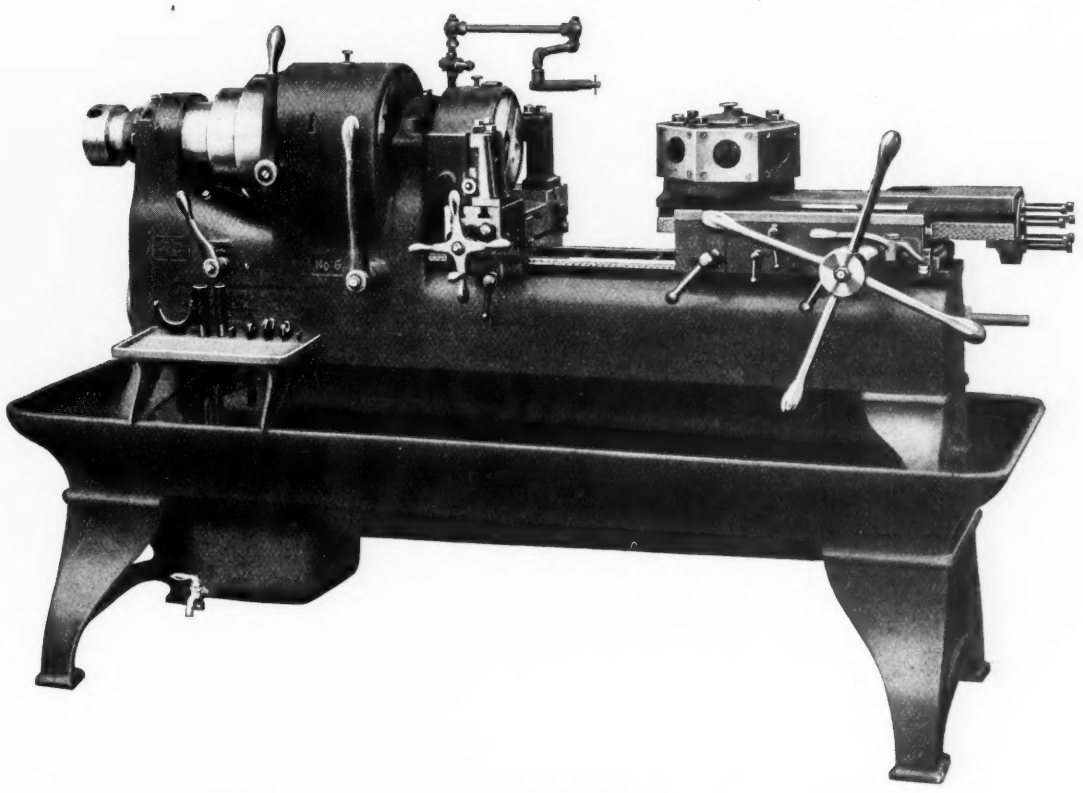
Henry K. Swinscoe has resigned the position of assistant superintendent of the South Works of the American Steel & Wire Co., Worcester, Mass., to enter the employ of the Morgan Spring Co., of Worcester, as superintendent.

Clifford F. Kern, formerly president of the Kern Machine Tool Co., Hamilton, Ohio, has disposed of his interest in that company and purchased the Von Wyck Machine Tool Co. of Cincinnati, manufacturer of 15-inch engine lathes.

Fred R. Jochmus, who for several years has been assistant foreman in the machine shop department of the Remington Arms–Union Metallic Cartridge Co., at Ilion, N. Y., has been appointed foreman of the machine shop department.

F. B. Jacobs, for several years in the employ of the Carborundum Co., Niagara Falls, N. Y., in various capacities, and

These machines are adapted for the rapid production of duplicate parts in small lots



B. & S. Wire Feed Screw Machines

Unless the volume of any one kind of work in a shop is sufficient to warrant the installation of automatic machines, the wire feed type is the most economical to employ. Because they are adapted for such work, they embody many conveniences to aid in setting up and operating.

A glance at the sizes of the machines in the line will emphasize their range. They are as follows:

No. 0 takes stock $\frac{3}{8}$″ diameter; turns to $2\frac{1}{4}$″ length.

No. 1 takes stock $\frac{3}{4}$″ diameter; turns to 3″ length.

No. 2 takes stock $\frac{7}{8}$″ diameter; turns to 5″ length.

No. 4 takes stock $1\frac{1}{4}$″ diameter; turns to 8″ length.

No. 6 takes stock $1\frac{1}{2}$″ diameter; turns to 10″ length.

See our Catalogue for detailed descriptions. Sent on request.

BROWN & SHARPE MFG. CO.

Providence, R. I., U. S. A.

a frequent contributor to MACHINERY, has resigned from his position as salesman in the company's Philadelphia office.

Edward K. Hammond of Chicago, a frequent contributor to the technical press, has joined the editorial staff of MACHINERY. Mr. Hammond is a graduate of Armour Institute of Technology, and has had practical shop and editorial experience.

Corneil Ridderhof, formerly treasurer and manager of the Wilmarth & Morman Co., Grand Rapids, Mich., and an occasional contributor to MACHINERY, has taken a position as assistant manager of the Western Gas Engine Corporation, Los Angeles, Cal.

Charles A. Schaefer, formerly general foreman of Schumacher & Boye, and for fourteen years with that company, has taken a position as superintendent of the John B. Morris Machine Tool Co., Cincinnati, O., manufacturer of lathes and radial drills.

Frank J. Lapointe, secretary of the J. N. Lapointe Co., who has been acting as superintendent of the works, will now give his whole attention to the engineering department of said concern, as Mr. Robert Cary, formerly of the Gisholt Machine Co., Warren, Pa., is now the superintendent.

Walter B. Snow, publicity engineer, 170 Summer St., Boston, has recently increased his staff by the addition of Mr. Fred R. Lufkin, formerly of the instruction staff in electrical engineering of the Massachusetts Institute of Technology, and late assistant superintendent of lighting and wires of Brookline, Mass.

Joseph Wolf, formerly of the Hisey-Wolf Machine Co., Cincinnati, Ohio, has become interested in the Cincinnati Electrical Tool Co., and has been made vice-president and general manager. The company makes portable electric drills and grinders and Mr. Wolf will take entire charge of the management of the business.

E. P. Bullard, Jr., president of the Bullard Machine Tool Co., delivered an address Tuesday evening, November 26, before the Cleveland Engineering Society in Cleveland, Ohio, on the subject, "A New Era in Machine Design," in which the basic principles of the design and construction of machines which will fully meet the new requirements of the present-day manufacturer, were discussed.

E. J. Kearney, president of the Kearney & Trecker Co., Milwaukee, Wis., who was very ill with pneumonia in Boston, at the time of the recent National Machine Tool Builders' Association's annual convention in New York, has recovered, after having been confined to the hospital for five weeks. Mr. Kearney is gradually regaining his strength, and recently passed through New York on his way home with Mrs. Kearney, traveling by easy stages.

Henry Hess has resigned as president of the Hess-Bright Mfg. Co. and has sold all of his holdings in that company. It is understood that no change in the policies of the company is contemplated. Mr. Hess became interested in ball bearings while general director of the German Niles Tool Works. The Deutsche Waffen-und Munitions Fabriken ball bearings had just become famous through their use in the German Mercedes automobile in the winter of 1901. Up to this time all the early types of ball bearings had been failures as applied to automobiles. Owing to its novel mechanical features and high efficiency, the German Mercedes car made a great sensation, and the general adoption of ball bearings in automobiles soon followed. Armed with the American rights of the DWF ball bearings, Mr. Hess came to this country and in 1904 formed the Hess-Bright Mfg. Co. The company started with a small one-room office, and grew until today it owns a new factory and thirteen acres of land at Front St. and Erie Ave., Philadelphia. The history of the company is, in part, Mr. Hess's history. At first the bearings were used only in automobiles. Since then, however, the field has broadened, and Mr. Hess has made applications of the bearings in many other types of machines in the industrial world, especially adapting them for use at points where plain bearings would not stand up, as where high speed is necessary. Mr. Hess has contributed largely to the technical literature of ball bearings and is looked upon as one of the foremost authorities in America on the subject. He was judge of the mechanical exhibit at the St. Louis Exposition; he is a member of the council of the American Society of Mechanical Engineers, a former president of the Society of Automobile Engineers, and chairman of the Philadelphia Branch, president of the Engineers Club of Philadelphia and a member of the fair practice committee of the Motor and Accessories Manufacturers Association.

COMING EVENTS

December 3-6.—Annual meeting of the American Society of Mechanical Engineers in New York. Calvin W. Rice, secretary, 29 W. 39th St., New York.

December 5-7.—Sixth annual convention of the National Society for the Promotion of Industrial Education in Philadelphia, Pa. Headquarters, Hotel Walton. C. A. Prosser, secretary, 105 East 22d St., New York.

January 11-18.—National Association of Automobile Manufacturers show of pleasure vehicles at Madison Square Garden, New York. M. L. Downs, secretary, 7 East 42d St., New York.

January 20-25.—National Association of Automobile Manufacturers show of auto-truck and delivery cars at Grand Central Palace, New York. M. L. Downs, secretary, 7 East 42d St., New York.

NEW BOOKS AND PAMPHLETS

ROAD LEGISLATION AND ADMINISTRATION IN IOWA. By John E. Brindley. 112 pages, 8⅝ by 5¾ inches. Three tables of information on road legislation and administration. Published by the Engineering Experiment Station, Iowa State College of Agriculture and Mechanical Arts, Ames, Iowa, as Bulletin No. 28.

TABLE OF ANGLES OBTAINABLE ON THE DIVIDING HEAD. Prepared and published by C. W. Ripsch and P. W. Hirsch, 113 Hawthorn St., Dayton, O. Price 25 cents.

These tables were prepared to meet the needs of machinists and toolmakers who are required to find angles on the dividing head of the milling machine quickly. The tables cover all the angles obtainable by simple indexing, using the plates furnished with the machine and an additional plate containing ninety holes, and are calculated to the nearest second.

THE A B C OF THE DIFFERENTIAL CALCULUS. By William Dyson Wansbrough. 148 pages, 7⅝ by 5⅛ inches. 30 illustrations. Published by D. Van Nostrand Co., New York. Price $1.50.

The object of this little book, which is clearly expressed by the title, is to present the essential details of the differential calculus in as concise and readily understandable a manner as possible. The present is the third edition, and is practically unchanged. The book can be recommended to those who wish to study the calculus at home. The subject is presented simply and progressively; the language often is unmathematical and the examples are drawn from everyday practice.

EMERY AND THE EMERY INDUSTRY. By A. Haenig. 103 pages, 7½ by 5 inches. 45 illustrations. Published by D. Van Nostrand Co., New York. Price $2.50.

The development of competition in the machinery industry has fully justified the expression that "time is money." This condition has led to the development of many forms of machinery that not only assist the workman in carrying out certain operations, but in many cases, actually do away with a large amount of hand work. Among such improvements, the substitution of emery wheels for the old type of grindstone, or for the file, has found wide application. In the present text, the author presents to both the engineer and layman, a general discussion of the subject of emery and the emery industries, treating of the raw materials, the finished wheels, and machines used to drive them, in the classes of work where they find application.

THE MECHANICAL WORLD POCKET DIARY AND YEAR BOOK FOR 1913. 330 pages, 6¼ by 4¼ inches. 71 illustrations. Published by Emmott & Co., Ltd., 65 King St., Manchester, England.

The latest edition of this annual contains a variety of useful information on mechanical engineering which is presented in convenient form for reference. The opening chapters deal with subjects pertaining to power installations and cover steam, gas and oil units. Following this section comes information on power transmission with useful tables on the standard dimensions of equipment used for this purpose. A considerable amount of useful information on machine shop practice is also presented chiefly in tabular form. In addition, the book contains a number of tables on the characteristics of engineering materials and also tables of mathematical constants. Considering the low publisher's price—six pence— this book is a remarkably cheap and valuable handbook.

FORGING, STAMPING AND GENERAL SMITHING. By Benjamin Saunders. 428 pages, 8¾ by 5¾ inches. 728 illustrations. Published by Spon & Chamberlain, 123 Liberty St., New York. Price $7.50, net.

The information presented in this book will be found of value to foreman-blacksmiths, engineers and managers, and others concerned with the operation of blacksmith shops. The text includes matter on forging, stamping and general smithing, the methods in each case being freely illustrated and described in a concise and readily understood manner. The author is, himself, a practical foreman-blacksmith and has drawn his information from a wide experience with the subject upon which he writes. One of the points of particular value is that the time required to complete given operations is indicated in connection with the description of the method to be followed. The time and other data presented have been carefully verified by the writer; the work, therefore, may be taken as a guide by those who are looking into the efficiency of blacksmith shop operation.

GASOLINE ENGINES; THEIR OPERATION, USE AND CARE. By A. Hyatt Verrill. 275 pages, 7½ by 5¼ inches. 152 illustrations. Published by Norman W. Henley & Son, New York. Price $1.50.

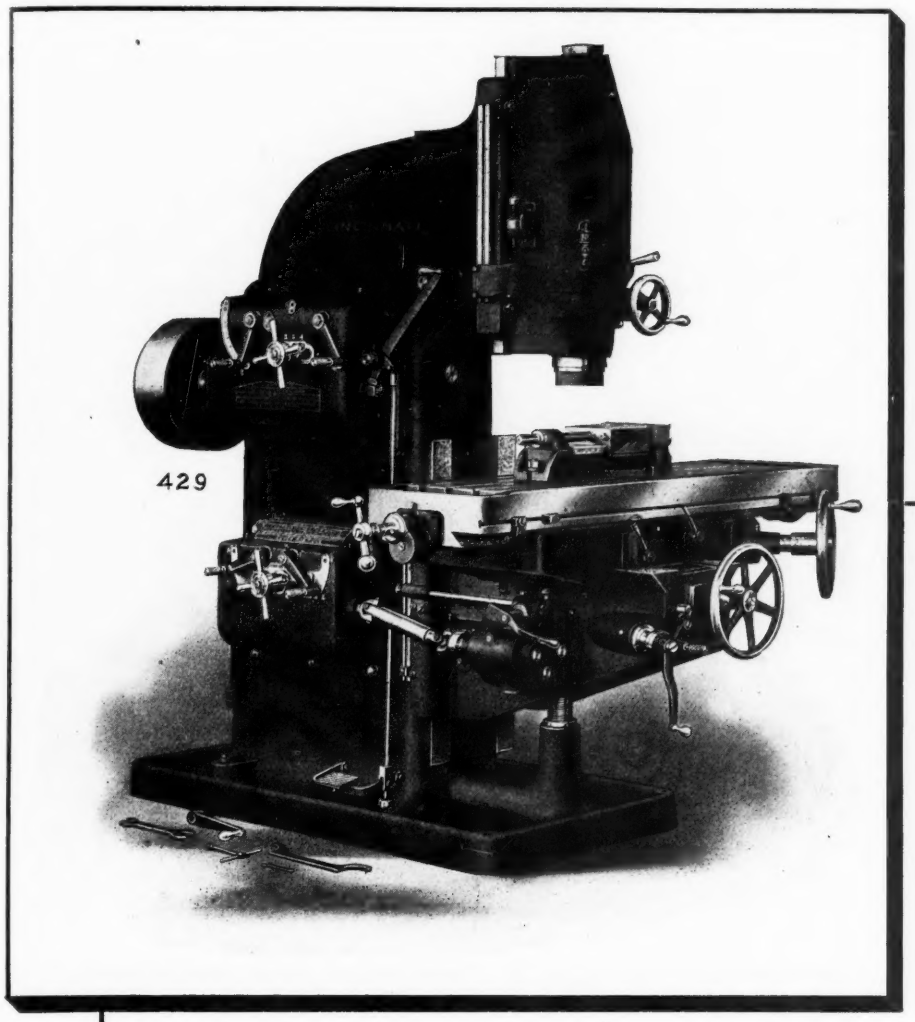
The wide application of gasoline engines to motor-driven vehicles and to a variety of classes of stationary service, has created a need for a book dealing with the methods of operating and caring for this type of equipment. The subject is one which affords an opportunity for highly technical treatment, but such a text would be of little value to the many users of gasoline engines who are non-technical men. It is for the use of such readers that the present volume has been written. The text gives all necessary information concerning the operation and care of gasoline engines in simple language, and the use of technical terms has been avoided as far as possible. There are certain cases, however, where technical terms have to be used, as for instance, in ordering new parts, but to make these clear, a glossary has been included which gives the meaning of all the technical terms used.

SOFT SOLDERING, HARD SOLDERING AND BRAZING. By James F. Hobart. 190 pages, 7 by 4¾ inches. 62 illustrations. Published by D. Van Nostrand Co., New York. Price $1, net.

Some mechanics believe that the operations of soldering and brazing are comparatively simple, requiring no special degree of skill or experience on the part of the workman. As a matter of fact they involve a wide range of manipulations, and frequently demand experienced workmanship of a high order. At the same time, so many mechanics are accustomed to performing soldering operations with tools and appliances which might be greatly improved upon, that the author has been led to offer this book in the hope that it will serve as a practical aid to an improvement of methods. If such a purpose can be accomplished, the interests of both mechanics who seek advancement and employers who are awake to the importance of efficiency and economy, will be advanced by a careful study of this volume. The different phases of soldering and brazing are dealt with, the subject matter being based upon the author's experience in this work.

TOOTHED GEARING. By George T. White. 217 pages, 7⅜ by 4¾ inches. 136 illustrations. Published by D. Van Nostrand Co., New York. Price $1.25.

This book is presented by the author with the view of explaining simply the action of the principal forms of gear teeth. The two forms of tooth profile in most common use—the cycloidal and the involute—have been considered in detail, neither being strongly advocated in preference to the other. On cut gears, the involute curve is preferred to the cycloidal, and has almost entirely displaced it on such wheels. This change has gone so far that the involute form may very shortly become the generally accepted standard the world over for machine-cut teeth. The contents by chapter heads are: Kinematics; The Spur Wheel—Cycloidal Teeth; Annular Wheels—Cycloidal Teeth—; The Spur Wheel—Involute Teeth; Obliquity of Action, etc.; Pin Gearing; Non-Circular Wheels; Lobed Wheels; Helical Wheels; Bevel Wheels; Skew Bevel Wheels; Worm-Gearing; Oblique Worm and Wheel; Screw Wheels or Spiral Wheels; Strength of Teeth; Durability; Trains of Wheels; The Odontograph.



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HOW TO READ A DRAWING. By Vincent C. Getty. 64 pages, 9¾ by 6⅝ inches. 61 illustrations. Published by J. B. Lippincott Co., Philadelphia and London. Price $1, net.

There is probably no study of more general use to the practical mechanic than the reading of drawings. No matter what class of work he is engaged upon there will be constant occasion for him to use drawings in carrying on his work. This knowledge can be readily acquired by the young mechanic without being well informed on engineering or other technical matters, as it is only necessary for him to be able to read English to enable him to acquire a working knowledge of mechanical drawings. In presenting this book, the author has endeavored to explain the methods of reading a drawing without the use of technical terms, but where it has been absolutely necessary to include such terms an explanation of them has been given. The main principles of drawing are thoroughly explained and sufficient examples are given to enable anyone to clearly understand a drawing which may be placed before him. This is a book which is particularly adapted to home study and should enable any mechanic to acquire knowledge upon a subject that will be of particular value to him.

PRACTICAL MATHEMATICS. By Claude Irwin Palmer. Part I. Arithmetic With Applications; 139 pages, 7⅛ by 4¾ inches. 20 illustrations. Part II, Geometry with Applications; 149 pages, 7⅛ by 4¾ inches. 130 illustrations. Published by McGraw-Hill Book Co., 239 West 39th St., New York. Price 75 cents, net, per volume.

The subject of mathematics is one with which many mechanics are insufficiently acquainted, and the realization of this fact causes many to attempt to remedy the deficiency by attending evening classes. During the past eight years Mr. Palmer has taught evening classes in mathematics comprising a total of over 500 men, and has prepared the text to meet the requirements of such students. In all cases, the subject matter has been made as practical as possible in order that its application to actual problems which the students will subsequently encounter in the shop, may be made as easy as possible. The series will be completed by two other volumes covering the subjects of algebra and trigonometry, and it appears that the complete text should meet a need in presenting mathematical subjects in evening classes, continuation schools, etc., which are primarily intended for the education of practical men of somewhat advanced years.

THE THEORY OF ENGINEERING DRAWING. By Alphonse A. Adler. 312 pages, 9 by 6½ inches. 273 illustrations. Published by D. Van Nostrand Co., New York. Price $2.

The subject matter of this volume is largely the same as that of many other treatises on descriptive geometry but the author has given it the title "Theory of Engineering Drawing," believing that this indicates the ultimate purpose of the book in a better way. The text was written with the purpose of correcting certain weaknesses in the presentation of the subject of descriptive geometry, and emphasizes the fact that the student is concerned with the representation on a plane of objects in space or three dimensions. Although analysis is important as affecting primary purposes, the development of methods for representation and interpretation of the resulting drawings cannot be regarded as an end in itself. The number of fundamental principles treated in the text has been reduced to a minimum; indeed it will be found that the entire text is based on the problem of finding the piercing point of a given line on a given surface, together with a few additional problems. The author believes that this method of treatment has simplified the presentation of a somewhat abstract subject, so that it may be more readily grasped by the average student.

PETROL ENGINE CONSTRUCTION AND DRAWING. By W. E. Dommett. 55 pages, 11 by 8½ inches. 26 illustrations. Published by Longmans, Green & Co., Fourth Ave. and 30th St., New York. Price 75 cents, net.

Existing books on machine design have failed to present information to meet the requirements of draftsmen engaged in work dealing with petrol engines and to meet this requirement, a series of drawings was prepared for use at Guildford and Kingston-on-Thames Technical Institutes. These drawings have been embodied in the present book with the view of compiling a text to meet the requirements of technical students, engineers, apprentices and junior draftsmen, who are either engaged on work in connection with petrol (gasoline) engines or are otherwise interested in the subject. Some of the dimensions in these drawings are given in millimeters on account of the extensive use of this system on the continent of Europe. For purposes of reference, a very brief description has been given of the four-cycle and two-cycle engines. The purpose of so doing has been to encourage the student-draftsman to enter into the mechanical principles underlying the operation of the parts which he is drawing in addition to simply producing a view of them for the use of the engineering department. In view of the wide application of petrol engines on motor cars, marine vessels, aeroplanes and stationary engines, it is believed that this work should be one of considerable value.

THE MODERN GASOLINE AUTOMOBILE. By Victor W. Page. 693 pages, 8⅝ by 6 inches. 380 illustrations. Published by Norman W. Henley & Son, New York. Price $2.50.

In preparing this book, the author's object has been to develop a text on the modern gasoline automobile which will be readily understood by non-technical readers. The usefulness of such a book will be readily appreciated when it is remembered that a large number of the owners of automobiles are business and professional men who have very little mechanical knowledge. The present book has been written primarily for the benefit of such readers and with this purpose in view, technical terms have been eliminated from the text as far as possible. At the same time, the author has appreciated the necessity of entering into a considerable amount of detail in order to present the subject in an adequate manner. This is probably one of the most striking differences between this book and preceding books which have been written by other authors with the view of covering the same subject. It is an established fact among automobile builders and sales agencies that many persons are deterred from purchasing an automobile, not on account of lack of means for the initial investment or provision for maintenance, but owing to the somewhat general belief that the upkeep of a car requires considerable mechanical ability. While this is undeniably true, any business man should be able to acquire much of the necessary knowledge concerning the operation and maintenance of a car from Mr. Page's book.

HYGIENE FOR THE WORKER. By Dr. William H. Tolman. 231 pages, 7⅜ by 5¼ inches. Profusely illustrated. Published by the American Book Co., New York. Price 59 cents, postpaid.

It has been truly said that good health is the first requisite of success in any business undertaking. This is particularly true in the case of industrial workers who are more or less dependent upon physical strength in earning their livelihood. Dr. Tolman has had unusual opportunities for studying the conditions governing the health and general welfare of industrial workers and has developed his text with the particular object of making it acceptable reading for workers who are just starting upon their business career. The fault of many books intended to teach methods of hygiene is that they have been made more or less dependent upon a knowledge of anatomy. In the present book, such scientific terms have been entirely eliminated and a simple description is given of the necessary steps for the young worker to take in order to preserve his health and vitality in the best possible working condition. The book is freely illustrated with drawings especially prepared for the purpose and should be of particular interest and value to the class of readers for which it is intended. The chapter titles are as follows: Applying for a Position; Preparing for the Day's Work; Good Habits for the Workmen; Suitable Clothing; Food and Drink; Alcohol and Tobacco; The Noon Hour; Hygiene of the Workroom; Fatigue; After Hours; Holidays and Outings; Choice of Occupation; Occupational Dangers—Accidents; Occupational Dangers—Poisons and Fumes; Fire; First Aid to the Injured; Tuberculosis, etc.

COMMERCIAL ENGINEERING. By "A General Manager" (Alfred B. Liversedge). 369 pages, 8¾ by 6⅛ inches. Published by Emmott & Co., Ltd., 65 King St., Manchester, England. Price $1.80.

The text presented in this book reproduces a series of articles which recently appeared in the *Mechanical World*. The primary aim of the text was to fill in the gap which exists between the information acquired from any form of technical or business education and the actual application of the knowledge so acquired in commercial or engineering fields of endeavor. Business aptitude or the ability to handle engineering work to advantage can only be acquired through years of actual experience, and such experience necessarily entails making a start in positions of minor importance. One of the objects of the matter presented in this text is to afford a means for employes holding positions of minor importance to get in touch with the work carried on by the directing officials of large corporations. It is believed that a study of such methods will prove of particular value, as a knowledge of the workings of the organization of large corporations will place the employe in a position to undertake readily the duties of a more important position, when the opportunity of so doing presents itself. In addition, this book presents information which should be of value to the man higher up in pointing out the possibilities of markets which exist for engineering products, and the best methods of conserving these markets for his company. One of the valuable features of the method of presentation of this text is that it will appeal to a wide circle of technical readers occupying positions of varying importance.

NEW CATALOGUES AND CIRCULARS

EDWIN BURHORN CO., 71 Wall St., New York. Catalogue of Burhorn and "Acme" cooling towers.

AMERICAN ENGINEERING CO., Philadelphia, Pa. Report of tests made on Taylor gravity underfeed stokers.

NEW JERSEY FOUNDRY & MACHINE CO., 90 West St., New York. Circular of cranes, tracks, trolleys and hoists.

GREEN FUEL ECONOMIZER CO., Matteawan, N. Y. Booklet entitled "Best Proportions of Boiler and Economizer Surface."

GEORGE NASH CO., 217 Pearl St., New York. Card illustrating "Perfection" spring winder for winding springs by hand or in the lathe.

OTTO GAS ENGINE WORKS, 33d and Walnut Sts., Philadelphia, Pa. Special number of the *Otto Cycle* describing the Otto horizontal crude oil engine operating on the Diesel principle.

W. S. ROCKWELL CO., 50 Church St., New York. Catalogue 16 on semi-automatic furnaces for annealing, hardening, tempering, and heat treating, aluminum, brass, copper, german silver, sterling silver, steel, etc.

KERN MACHINE TOOL CO., Hamilton, Ohio. Circular of sixteen-inch ball bearing, sensitive type, drilling machines furnished in 1-, 2-, 3- and 4-spindle combinations, with and without table elevating screw.

EMMERT MFG. CO., Waynesboro, Pa. Catalogue No. 12 of Emmert vises, comprising patternmakers' and woodworkers' universal vises, toolmakers' and machinists' universal vises, machinists' plain vises and combination pipe vises.

DE LAVAL STEAM TURBINE CO., Trenton, N. J. Booklet on the new De Laval steam turbines with velocity stages, built in sizes up to 600 H. P., and suitable for direct connection to centrifugal pumps, blowers, small generators, etc.

WATSON-STILLMAN CO., 192 Fulton St., New York. Catalogue No. 88 on hydraulic leather belt presses, listing six distinct types of leather presses; also hydraulic pumps, accumulators, fittings, etc., generally required with hydraulic presses.

OTIS ELEVATOR CO., 11th Ave. and 26th St., New York. Catalogue of inclined elevators for quick handling of freight and merchandise, truck elevators, overhead carriers, dock elevators, ramp elevators, dumbwaiters, horizontal conveyors, etc.

GEORGE W. RICHARDSON, 4212-16 24th Place, Chicago, Ill. Circular of the Richardson direct-reading metal slide-rule, having distinctive features; also Johnson's combination pocket rule made of german silver, forming a hook-rule, caliper-gage, protractor, triangle, or try-square.

GREEN FUEL ECONOMIZER CO., Matteawan, N. Y. Catalogue of standard and special fuel economizers; mechanical draft outfits; heating, ventilating and drying outfits; hot blast heaters; steel plate fans; motor- and engine-driven fans, cast-iron volume blowers, exhausters, etc.

CINCINNATI PRECISION LATHE CO., Cincinnati, O. Catalogue of Cincinnati precision lathes which have the following features: no cone pulleys, continuous spindle bearings, absence of belt pull on spindle, variable speed and reverse without shifting of belts, permanency of alignment, etc.

COCHRANE-BLY CO., Rochester, N. Y. Circular on the Cochrane-Bly universal shaper which was illustrated and described in the October number. The shaper is designed especially to meet the needs of tool- and die-makers, being adapted to produce accurate work on dies, special tools, jigs, etc.

CELFOR TOOL CO., Buchanan, Mich. Table of feeds and speeds for Celfor drills working in cast iron, medium and hard or very tough steel, ranging from ¼ inch to 3 inches diameter. The tables are printed on "Crystaloid," in convenient shape for hanging up in the shop for ready reference.

HESS-BRIGHT MFG. CO., 17 E. Erie Ave., Philadelphia, Pa. Data sheets on ball bearings comprising propeller shaft ball bearings, mounting for double exhaust fan, two direction thrust bearings, special bearings for automobile steering pivots, vertical shaft bearings, and classified index to titles of ball bearing data sheets.

CROCKER-WHEELER CO., Ampere, N. J. Bulletins Nos. 150 and 158, superseding Bulletins Nos. 114, 133 and 123, on coupled and belt type alternating-current motors two- and three-phase 50 KVA and up; and adjustable speed motors 1/3 to 32 H. P., speed ranges 2 to 1, 2.5 to 1 and 3 to 1, made in eleven frame sizes.

MANNING, MAXWELL & MOORE, 85-89 Liberty St., New York. Twelve page bulletin descriptive of Shaw electric monorail system with fixed tongue switch which effects an advance and improvement in monorail construction, eliminating the danger of accidents and delays incident to the use of the moving-tongue type.

FOSTER MACHINE CO., Elkart, Ind. Circular of plain head and geared head turret lathes, plain head and geared friction head screw machines, universal or set-over turret lathes, special friction head

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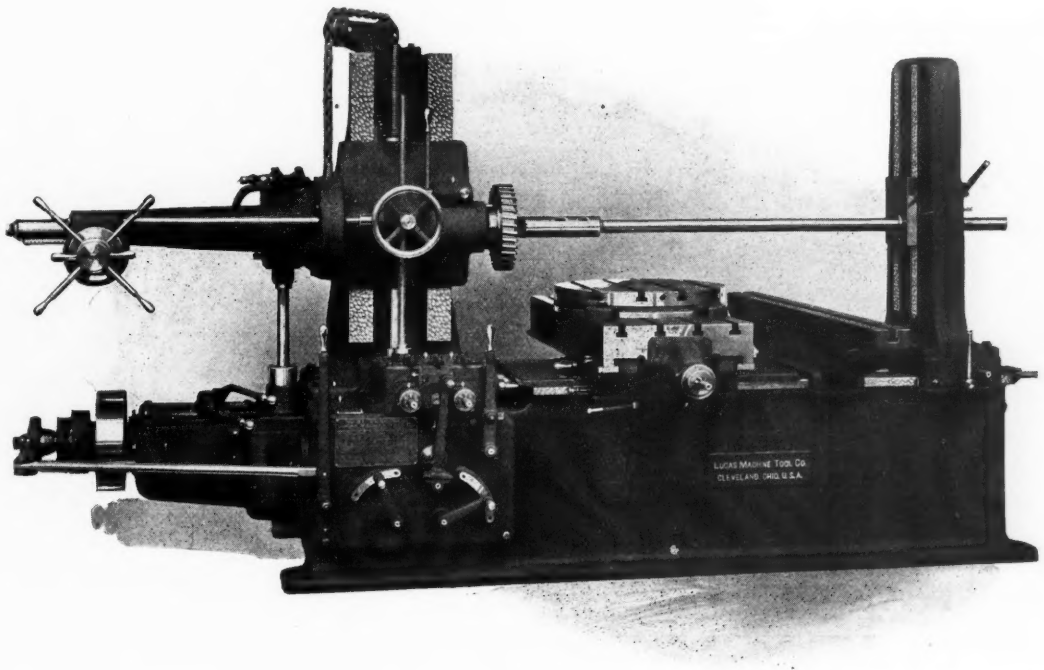

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screw machines, cock grinder for grinding water and gas cocks up to two inches diameter, tap holders, box tools and other accessories.

VULCAN ENGINEERING SALES CO., Fisher Bldg., Chicago, Ill. Catalogue of punches, shears, rolls, bulldozers, etc., made by the Rock River Machine Co., comprising the "Badger" single end punch and shear, "Badger" single end punch, "Badger" coping punch, "Badger" power plate bending roll and air compressors for general purposes.

PLATT IRON WORKS CO., Dayton, Ohio. Catalogue of Platt horizontal and vertical centrifugal pumps, illustrating different forms of centrifugal pumps adapted to many kinds of service. Users of this apparatus will find interesting and valuable data on the general subject of centrifugal pumps and the conditions necessary for their economical use.

DE LAVAL STEAM TURBINE CO., Trenton, N. J. Catalogue and treatise on the De Laval steam turbines, containing 120 pages, 6 by 9 inches. The relative advantages of the several fundamental types of turbines are discussed and much space is devoted to a discussion of the "speed-compromise" problem. The publication is an interesting and valuable contribution to trade literature.

FOOTE BROS. GEAR & MACHINE CO., 210-220 North Carpenter St., Chicago, Ill. Price list of standard gears, comprising spur, bevel, worm gears, raw hide pinions and reducing gears. The catalogue contains 240 pages and comprises considerable data on gear elements that are required in the design and cutting of gearing; also weight tables, gages, drill sizes, thread shapes, power of belting, capacity of cisterns and tanks, etc.

NIAGARA MACHINE & TOOL WORKS, Buffalo, N. Y. Catalogue No. 50 of tools and machines for working sheet metals, tinsmiths' and roofers' tools, etc., comprising folders, brakes, bench machines, beaders, flangers, groovers, double seamers, forming rolls, tube formers, stakes, snips, roofing tools, gutter beaders, notchers, rotary shears, foot squaring shears, lever punches and shears, power squaring shears, power rotary shears, etc.

WILLIAM CRAMP & SONS SHIP & ENGINE BLDG. CO., Philadelphia, Pa. Pamphlet on gear bronzes describing six kinds, including Parsons' manganese bronze. The characteristics of each kind are given with illustrations showing application in use. The bronzes named range from the type suitable for light loads and high speeds to Parsons' manganese bronze adapted for heavy loads and slow speeds, under excessive strain and shock.

NATIONAL TUBE CO., Frick Bldg., Pittsburg, Pa. Bulletin No. 11 on "National" pipe, and defining "spellerizing" which is a method of treating metal. The heated bloom is worked by rolls having regularly shaped projections, and then by smooth face rolls, the result being a uniform dense texture of the steel which is better adapted to resist pitting and corrosion than is the structure of common steel. A list of bulletins published by the company is also included.

NATIONAL-ACME MFG. CO., Cleveland, Ohio. Calendar for 1912-13, made in the form of a wall pocket, having two openings through which the calendar for the month and advertisements of the National-Acme automatic screw machine appear. The leaves can be removed and transposed to the back, keeping the entire calendar for the year intact, if desired. The illustrations and print appear in white on a black background, creating a very pleasing effect. A limited supply is available for distribution.

GENERAL ELECTRIC CO., Schenectady, N. Y. Bulletin A 4037 on isolated and small plant switchboards; A 4036 (superseding bulletin 4917) on direct-current exciter panels; 4974 on current limiting reactances; 4993 (superseding bulletin 4858) on type RI single-phase motors; A 4004 (superseding bulletin 4836) on the G-E steam flow meter; A 4034 on type W long-life flame arc lamps; and A 4039 on direct-current motor-starting and speed-regulating rheostats and panels, superseding bulletins 4600, 4599, 4532 on the same subject.

PENNSYLVANIA R. R. CO., Philadelphia, Pa. Booklet on the American Land & Irrigation Exposition held in New York City November 15 to December 2 at the 71st Regiment Armory. The P. R. R. Co. in common with other progressive railroads, is educating farmers to produce more and better crops. Larger crops mean more freight and merchandise to be transported, more passengers and better dividends. The booklet is illustrated with examples of farm products and is one of a series of interesting and valuable farm publications issued by the company.

EARLE GEAR & MACHINE CO., Wyoming and Stenton Aves., Philadelphia, Pa. Pamphlet on herringbone gears describing their characteristics and superiority to spur gearing where smooth, uniform transmission is required. Examples of herringbone gears made by the company are illustrated, ranging up to 365 H. P. capacity, in which example the pitch diameters of the gearing and pinion are 76 and 11 inches, respectively, and the face width 21 inches. The pamphlet also illustrates examples of miter and bevel gears, wormwheel balanced gears, etc.

DEANE STEAM PUMP CO., 115 Broadway, N. Y. Catalogue D 167 on sand riddlers; D 169, on hydraulic air-charging device; D 171, on horizontal duplex piston pumps operated by direct-connected gasoline engines; D 202, on duplex steam pumps piston pattern; D 217, on duplex horizontal double-acting power pumps; D 220, on portable mine pumps, outside packed plunger pattern; D 219, on modern water works for town and city supply; supplement B to D 200, on deep well pumping machinery; D 222, on automatic pumps and receivers; D 224, on horizontal double-acting single-cylinder power pumps.

CANTON FOUNDRY & MACHINE CO., Canton, Ohio. Catalogue of "Universal" conductor pipe and eave-trough machinery, paint rolls, drop presses, melting outfits and dies for ceilings, sidings, cornices, etc. Circular of "Universal" garage equipment comprising turntables, jacks and floor cranes. Circular of "Canton" alligator shears made in five sizes ranging in capacity from 1½ inch square round or equivalent cross-section, soft steel or iron, to 3 inches square or equivalent section. Circular of portable floor crane and hoists for use in machine shops, factories, garages, etc. Circular of turntables for shop and factory railways.

DODGE MFG. CO., Mishawaka, Ind. Abridged catalogue 106-A-12 on power transmission machinery, comprising price lists of steel shafting; keyseating and shouldering shafting; keyseating iron and iron center wood rim pulleys, rope sheaves, etc.; safety collars; flange couplings; compression couplings; universal joint couplings; shaft hangers and adjustable pillow blocks; adjustable ball-and-socket drop and post hangers; countershafts; step bearings; bearing metals; belt tighteners, friction clutches; cut-off couplings; adjustable mule stands; wood split pulleys; iron center wood rim pulleys; machine molded solid iron pulleys, standard iron split pulleys, etc.

VULCAN ENGINEERING SALES CO., Fisher Bldg., Chicago, Ill. Catalogue No. 3 of Hanna pneumatic standard riveters, screen shakers, revolving dumping riddles, oscillators, mold dryers, etc. The principle of the interesting toggle mechanism of the riveter is clearly shown in outline illustrations and by a view of a model furnished to salesmen. Among the advantages claimed are one blow to a rivet, saving of time and air, heavy predetermined compression, reduced wear and tear, etc. The "anatomy" of the Pedrick and Ayer hydro-pneumatic riveter, also controlled by the company, is shown with list of parts. A list of users of Hanna riveters, 1912, and testimonials from users are issued in separate pamphlets.

NEW DEPARTURE MFG. CO., Bristol, Conn., manufacturer of "New Departure" ball bearings, has issued a series of data sheets devoted exclusively to the adaptability of these bearings to machine tools and shaft hangers. The data sheets cover the three types of ball bearings of "New Departure" manufacture, each of which has its peculiar qualifications. The sheets are 8½ by 11 inches, printed on one side, and have two holes punched in one edge for a loose-leaf binder. They show the design of specific mountings in a milling machine head, speed cones and driving pulley of a drilling machine, an air compressor base with layshaft and crankshaft, a high-speed grinding spindle and a grinding or polishing head. The construction of the "New Departure" shaft hanger is illustrated and described. This hanger is equipped with a ball bearing developed especially for the service. The sheets and loose-leaf binder will be sent free to any address on request, when written on the letter paper of manufacturing concerns.

TRADE NOTES

REED MFG. CO., Erie, Pa., manufacturer of vises, has erected a one-story brick addition 50 by 200 feet.

J. N. LAPOINTE CO., formerly of Marlboro, Mass., manufacturer of broaching machines and broaches, has moved to its new factory in New London, Conn.

WILLIAMS TOOL CO., Erie, Pa., manufacturer of pipe tools and threading machines, has just erected a two-story brick addition for office purposes.

ONEIDA STEEL PULLEY CO., Oneida, N. Y., manufacturer of steel pulleys, has extended its plant by a one-story cement and steel addition 112 by 310 feet.

WAYO MFG. CO., 642 Ellicott Square, Buffalo, N. Y., has placed on the market a brush-bar belt dressing, consisting, of a bar of dressing with a leather brush fixed in one end for cleaning the belt before applying the dressing.

DUFF MFG. CO., N. S. Pittsburg, Pa., manufacturer of jacks, has recently placed an order with Tate-Jones & Co. of Pittsburg for a

THE DISCRIMINATING PIANO MANUFACTURER

buys the Felton & Guilleaume Imported Steel Music Wire because he has learned that the wire plays the most important part in the tone of the instrument. He has tried out many wires and he knows the Genuine F & G, in either the Black, Red or Green Label grades, is to be depended upon at all times for uniformity of strength and quality.

F & G Wire is now used, also, by manufacturers of Calculating Machines, Typewriters, Automatic Machines, Carpet Sweepers, Toys, Electrical Work, etc., and by hundreds of other manufacturers who have tried out scores of other makes and found by severe comparative tests that the F & G stands in a class by itself for staunch reliability.

If you have trouble in procuring what you need in High Grade Steel Wire, tell us your requirements and let us submit samples, or

Ask for descriptive circular No. 3076.

HAMMACHER, SCHLEMMER & CO.

HARDWARE TOOLS AND SUPPLIES,

4th Avenue and 13th Street **New York, Since 1848**

large double chamber heat-treating furnace, similar to the furnace installed some time ago by this company for the White Co. in Cleveland Ohio.

HESS-BRIGHT MFG. CO., 17 E. Erie Ave., Philadelphia, Pa., announces that the interests in the company owned by Mr. Henry Hess have been purchased by the German D. W. F. Co. (Deutsche Waffen-und Munitions Fabriken). The policy of the company will be directed by Mr. Bright, the new president. A. T. Bruezel is the secretary, and C. L. McCalla, treasurer.

EDGEMONT MACHINE CO., Dayton, Ohio, manufacturer of friction clutch pulleys and power transmission machinery, is now located in its new factory on National Ave. and Niebert St., Dayton. The new plant is large and modern in every respect and considerable new equipment has been installed which has increased the manufacturing capacity about four times.

SKINNER CHUCK CO., New Britain, Conn., has purchased the planer chuck business of the Francis Reed Co., Worcester, Mass, and has moved the stock of finished chucks and patterns to the plant at New Britain. The Francis Reed Co. manufactures a line of improved drilling machinery and has manufactured the Jordan planer chucks for upwards of twenty years, but has decided to concentrate on the manufacture of its line of drilling machinery.

UNION MFG. CO., New Britain, Conn., has taken over the manufacture of the hand-operated punch, shear and rod-cutting machine formerly made by P. G. H. Bennett & Co., Boston, Mass. The machine will be made in three sizes, and is intended for general use in machine shops, blacksmith shops, garages, etc., for wire and rod cutting, shearing bars and plates, and punching holes. The company will require no new manufacturing equipment for the production of this machine.

JOSEPH DIXON CRUCIBLE CO., Jersey City, N. J. At the regular monthly meeting of its board of directors held October 21, the following changes were made in the officers and directors, on account of the death of the vice-president, William H. Corbin: George E. Long, former treasurer, was elected vice-president to succeed Mr. Corbin; J. H. Schermerhorn, former assistant secretary and assistant treasurer, was elected a director and treasurer; and Albert Norris was elected assistant secretary and assistant treasurer.

NEW PROCESS RAW HIDE CO., Syracuse, N. Y., has just erected additions which make its plant the largest in the world devoted exclusively to gear making and to gear cutting. The additions are a four-story-and-basement wing, 65 by 180 feet, extending at right angles to the old building, and a heating plant in the rear 50 by 60 feet, housing three 125 H. P. boilers. The new buildings are fire-proof throughout, having steel framework, reinforced concrete walls, brick curtain walls, and steel window sashes. New equipment costing $100,000 has been installed.

STANDARD MACHINERY CO., Providence, R. I., has bought six acres in Auburn, R. I., and has made plans for the erection of three buildings. The new location is about four miles from the present plant in Providence, and is on the Shore Line division of the N Y., N. H. & H. R.R. The main building will be 175 feet by 350 feet; and the second building, 100 feet square; and the third building, 60 feet square. The group of buildings will provide about three times the floor area of the old plant. The company expects to occupy the new plant some time next spring.

PALMER-MOORE CO., Syracuse, N. Y., for the past two years builders of the Moore two-cycle automobile engine, has increased its capital to $200,000 fully paid in, and will at once begin the manufacture of motor trucks. T. G. Meachem is president of the corporation and T. W. Meachem, vice-president. Charles L. Palmer is secretary-treasurer. The large plant of the Syracuse Stove Works, including three and a half acres of land and 90,000 feet of floor space, has been purchased and will be equipped with new machinery with the view of turning out the first two hundred trucks within six months.

Miscellaneous Advertisements—Situations, Help Wanted, For Sale, etc.

Advertisements in this column, 20 cents a line, seven words to a line. The money should be sent with the order. Answers addressed to our care will be forwarded. Original letters of recommendation should not be enclosed to unknown correspondents.

AGENTS IN EVERY SHOP WANTED to sell my sliding calipers. Liberal commission. ERNST G. SMITH, Columbia, Pa.

AUTOMATIC AND SPECIAL MACHINES designed. Working drawings. Tracings. Special Tools and Fixtures designed. C. W. PITMAN, 3519 Frankford Ave., Philadelphia, Pa.

DRAFTSMAN AND DESIGNER.—A-1 experienced man on general factory work, including building, piping, jigs and special machines. Must have initiative and executive ability, be able to handle men and work up details. Some machine shop experience is desirable. Present and future will be attractive to an exceptionally able man. State age, experience, and salary expected. Good references necessary. New York District. Address Box 509, care MACHINERY, 49 Lafayette St., New York.

DRAFTSMEN AND MACHINISTS.—American and foreign patents secured promptly; reliable researches made on patentability or validity; twenty years' practice; registered; responsible references. EDWIN GUTHRIE, Corcoran Building, Washington, D. C.

DRAFTSMEN, TOOLMAKERS and MACHINISTS, learn how to find angles on any dividing head without figuring or change gears. Read them to the second, directly from our tables. First edition selling rapidly. Price 25 cents. RIPSCH & HIRSCH, 113 Hawthorn St., Dayton, Ohio.

DRAFTSMEN WANTED.—Applications solicited from men with either Ordnance Mechanical-Electrical, or Mechanical-Structural experience. State fully age, experience, education, and salary expected. Address Box 510, care MACHINERY, 49 Lafayette St., New York.

ENGINEERS, SUPERINTENDENTS, Designers, Draftsmen, Engineering Salesmen, Production Engineers and Mechanical Foremen will find it to their advantage to investigate our method of securing employment. Unless record can stand investigation don't bother about answering this ad. THE ENGINEERING AGENCY, INC. (Est. 1893), Monadnock Block, Chicago.

EXPERIENCED LATHE, PLANER, Shaper, Bench and Floor Hands. Apply SULLIVAN MACHINERY CO., Claremont, N. H.

FOR SALE.—6 ft. Pond Radial Drill; one 36 in. x 12 ft. and two 24 in. x 6 ft. Pond Planers; in good condition. THE Q. M. S. CO., Plainfield, N. J.

FOR SALE.—One right hand C. & G. Cooper girder frame Corliss engine, cylinder 10½-inch bore by 30-inch stroke, 100 R. P. M., developing 75 horsepower at 90 pounds steam pressure; 8-foot fly wheel with 15-inch face. Removed to replace with greater capacity. Low price for quick sale. STATE JOURNAL COMPANY, Lincoln, Nebraska.

FOR SALE.—Plant located at Reynoldsville, Pa., on Allegheny Valley and B. R. & P. Railroads; 10 acres of ground; four buildings, consisting of Upper Shop, approximately 360 feet x 65 feet, Lower Shop, approximately 220 feet x 75 feet, two-story Office Building and Storage House; three Boilers, each 150 H. P.; one Generator 150 kilowatts. Plant suitable for Sheet Metal, Light Structural or Light Foundry Work. Smaller shop equipped for traveling crane. Will be sold cheap, on reasonable terms. Address B. L. H., Room 1204, Westinghouse Building, Pittsburg, Pa.

GAS SAVING BRAZING FORGES. Send for circulars. LUCAS & SON, Bridgeport, Conn.

GENERAL FOREMAN.—Modern, inventive, energetic, executive ability, broad experience, toolroom and manufacturing, successful in producing results and handling help. Address Box 507, care MACHINERY, 49 Lafayette St., New York.

HAND SCREW MACHINE OPERATORS, milling machine hands and boring machine Bullard operators. First class only. Steady employment to good men. F. I. A. T., Poughkeepsie, N. Y.

INVENTORS—On American and foreign patents, and trademarks, consult BENJAMIN ROMAN, Park Row Building, New York. Patent treatise mailed gratis.

MECHANICAL ENGINEER WANTED to take charge of wood-working plant; state age, past positions, and salary expected to start. Address Box 508, care MACHINERY, 49 Lafayette St., New York.

PATENTS.—H. W. T. JENNER, patent attorney and mechanical expert, 608 F St., Washington, D. C. Established 1883. I make a free examination and report if a patent can be had, and the exact cost. Send for full information. Trade-marks registered.

SALESMEN—Young men, preferably between 23 and 28, with technical training, and some machine shop experience, to enter sales force, six months preliminary training. In reply, state age, education and shop experience. COLONIAL STEEL CO., Pittsburgh, Pa.

TEST INDICATORS.—H. A. LOWE, 1374 East 88th St., Cleveland, Ohio.

TOOL-HARDENING — CASE-HARDENING. —C. U. SCOTT, Davenport, Iowa.

WANTED.—Agents, machinists, toolmakers, draftsmen, attention! New and revised edition Saunders' "Handy Book of Practical Mechanics" now ready. Machinists say, "Can't get along without it." Best in the land. Shop kinks, secrets from note books, rules, formulas, most complete reference tables, tough problems figured by simple arithmetic, valuable information condensed in pocket size. Price post-paid $1.00, cloth; $1.25, leather with flap. Agents make big profits. Send for list of books. E. H. SAUNDERS, 216 Purchase St., Boston, Mass.

WANTED.—CAPABLE FOREMAN tool and die maker for excellent position in Middle West. Previous records must accompany application. Address Box 506, care MACHINERY, 49 Lafayette St., New York.

WANTED.—Copies MACHINERY, Engineering Edition, issues September, October, November and December, 1906; also April, May, June and July, 1908. State price. Box 501, care MACHINERY, 49 Lafayette St., New York.

WANTED.—DIE SINKERS on Drop Forged Work, also Drop Forgers. Must be first class men, able to earn highest wages paid. Address Employment Dep't., THE BILLINGS & SPENCER COMPANY, Hartford, Conn.

WANTED.—First Class Electrical Instrument Makers and Gridley and Brown & Sharpe Automatic Screw Machine Hands. Address Employment Department, WESTINGHOUSE ELECTRIC & MFG. CO., East Pittsburgh, Pa.

WANTED.—Five Toolmakers on Jigs and Fixtures—4 Shaper hands—3 Brown & Sharpe Surface Grinder operators—1 young man, 18 to 22 years, as assistant in testing department —3 inspectors for machine department, who must be able to read drawings. Steady employment and good opportunities for advancement. GENERAL ELECTRIC CO., Windsor, Conn.

WANTED IN PENNSYLVANIA.—By first-class machine tool concern. Man who is thoroughly familiar with inspection and premium systems. Must be a man who has done executive work in these lines in some up-to-date machine tool concern. A man who is able to work out the executive end of the premium system and who thoroughly understands inspection of the machine tool class. In reply state age, whether married or single, compensation received in previous positions and what is expected at the present time. Only absolutely reliable, efficient man need apply. Address Box 487, care MACHINERY, 49 Lafayette St., New York.

WANTED.—Let us quote you on casting and machining small brass parts. Address Box 489, care MACHINERY, 49 Lafayette St., New York.

WANTED POSITION as Master Mechanic, Superintendent of Construction, or Millwright, with or without organization. Holding good position but prefers change. All round man on Concrete, Steel or Frame Construction. 20 years' experience in shop or plant operation; strictest investigation invited. Foreign position preferred. Address Box 511, care MACHINERY, 49 Lafayette St., New York.

WANTED.—TOOL DESIGNER. Duties: designing, cutting tools for maximum production with minimum repair, supervising tool room work, reducing tool expense on productive work. In brief, an experienced man on modern cutting shapes and heat treatment, capable of maintaining the tool equipment in the most economical manner. Applicants requested to state fully their experience, present employment, and salary. KING SEWING MACHINE CO., Buffalo, N. Y.

WANTED.—TOOL MAKER experienced in brass drawing and screw machine work wanted by small factory in eastern Pennsylvania. Opportunity for man of enterprise and stability. Applicants will facilitate correspondence by stating experience, references, and wages expected. Address W. D. S., 1929 North Main Ave., Scranton, Pa.

WE ARE EXCEPTIONALLY WELL FITTED to build your light and medium weight machines on contract in reasonable lots. Can store finished material, shipping direct to consumer your single orders or in lots and take the factory end entirely off your hands. Best of shipping facilities. Prompt and efficient service. High class workmanship. Prices right. HOYSRADT & CASE, Kingston, N. Y.

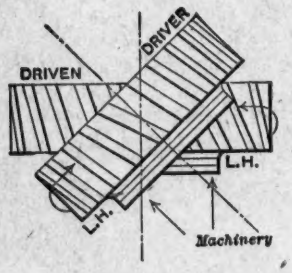
WELLES TOOLS are different. Get a catalogue and price list. WELLES CALIPER COMPANY, Milwaukee, Wis.

WORK WANTED for automatic screw machine up to 2" diameter. For vertical boring mills up to 10 ft. diameter. For large lathe up to 72" diameter, 12 ft. between centers. Address Box 512, care MACHINERY, 49 Lafayette St., New York.

YOUNG MECHANICAL ENGINEER with broad shop experience desires a change. Thoroughly posted on machine tools and modern manufacturing practice. Capable of handling practical and theoretical shop problems. Some experience, correspondence, office and commercial end. Would like to connect with manufacturer of high grade product where prospects for advancement are good. Location anywhere. Address Box 486, care MACHINERY, 49 Lafayette St., New York.

Contributed by James H. Carver

Shafts at 45 Degrees Angle, Ratio Equal, Center Distance Exact



The sum of the spiral angles of the two gears equals 45 degrees, and the gears are of the same hand, if each angle is less than 45 degrees. The difference between the spiral angles equals 45 degrees, and the gears are of opposite hand, if either angle is greater than 45 degrees.

Given or assumed:

1. Hand of spiral, depending on rotation and direction in which thrust is to be received.
2. P_n = normal pitch (pitch of cutter).
3. C = center distance.
4. α_a = approximate spiral angle of one gear.
5. β_a = approximate spiral angle of the other gear.
6. N = number of teeth nearest $\dfrac{2\,C\,P_n \cos \alpha_a \cos \beta_a}{\cos \alpha_a + \cos \beta_a}$

To find:

1. α and β = exact spiral angles found by trial from $\sec \alpha + \sec \beta = \dfrac{2\,C\,P_n}{N}$.
2. D = pitch diameter of one gear = $\dfrac{N}{P_n \cos \alpha}$.
3. d = pitch diameter of the other gear = $\dfrac{N}{P_n \cos \beta}$.
4. O = outside diameter of one gear = $D + \dfrac{2}{P_n}$.
5. o = outside diameter of other gear = $d + \dfrac{2}{P_n}$.
6. T = number of teeth marked on cutter for one gear = $N \div \cos^3 \alpha$.
7. t = number of teeth marked on cutter for other gear = $N \div \cos^3 \beta$.
8. L = lead of spiral for one gear = $\pi\, D \cot \alpha$.
9. l = lead of spiral for other gear = $\pi\, d \cot \beta$.

Example

Given or assumed:

1. See illustration. 2. $P_n = 8$. 3. $C = 10$ inches. 4. $\alpha_a = 15°$. 5. $\beta_a = 30°$.

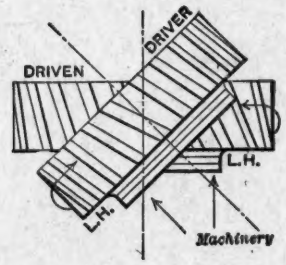
6. $N = \dfrac{2\,C\,P_n \cos \alpha_a \cos \beta_a}{\cos \alpha_a + \cos \beta_a} = \dfrac{2 \times 10 \times 8 \times 0.96593 \times 0.86603}{0.96593 + 0.86603} = 73$ teeth.

To find:

1. α and β from $\sec \alpha + \sec \beta = \dfrac{2\,C\,P_n}{N} = \dfrac{2 \times 10 \times 8}{73} = 2.1918$; by trial α and β, respectively, $= 14° 44'$ and $30° 16'$.
2. $D = \dfrac{N}{P_n \cos \alpha} = \dfrac{73}{8 \times 0.96712} = 9.435$ inches. 3. $d = \dfrac{N}{P_n \cos \beta} = \dfrac{73}{8 \times 0.86369} = 10.565$ inches.
4. $O = D + \dfrac{2}{P_n} = 9.435 + \dfrac{2}{8} = 9.685$ inches. 5. $o = d + \dfrac{2}{P_n} = 10.565 + \dfrac{2}{8} = 10.815$ inches.
6. $T = N \div \cos^3 \alpha = 73 \div 0.904 = 81$ teeth. 7. $t = N \div \cos^3 \beta = 73 \div 0.645 = 113$ teeth.
8. $L = \pi\, D \cot \alpha = \pi \times 9.435 \times 3.803 = 112.72$ inches.
9. $l = \pi\, d \cot \beta = \pi \times 10.565 \times 1.714 = 56.889$ inches.

Contributed by James H. Carver

Shafts at 45 Degrees Angle, Ratio Equal, Center Distance Approximate



The sum of the spiral angles of the two gears equals 45 degrees, and the gears are of the same hand, if each angle is less than 45 degrees. The difference between the spiral angles equals 45 degrees, and the gears are of opposite hand, if either angle is greater than 45 degrees.

Given or assumed:

1. Hand of spiral, depending on rotation and direction in which thrust is to be received.
2. C_a = approximate center distance.
3. P_n = normal pitch (pitch of cutter).
4. α = angle of spiral of driving gear.
5. β = angle of spiral of driven gear.
6. N = number of teeth nearest $\dfrac{2\,C_a\,P_n \cos \alpha \cos \beta}{\cos \alpha + \cos \beta}$

To find:

a. When spiral angles are 22½ degrees.

1. D = pitch diameter = $\dfrac{N}{0.9239\,P_n}$ 2. O = outside diameter = $D + \dfrac{2}{P_n}$
3. T = number of teeth marked on cutter = $N \div 0.788$.
4. L = lead of spiral = $7.584\,D$.
5. C = center distance = D.

b. When spiral angles are other than 22½ degrees.

1. D = pitch diameter of driver = $\dfrac{N}{P_n \cos \alpha}$ 2. d = pitch diameter of driven gear = $\dfrac{N}{P_n \cos \beta}$
3. O = outside diameter of driver = $D + \dfrac{2}{P_n}$.
4. o = outside diameter of driven gear = $d + \dfrac{2}{P_n}$.
5. T = number of teeth marked on cutter for driver = $N \div \cos^3 \alpha$.
6. t = number of teeth marked on cutter for driven gear = $N \div \cos^3 \beta$.
7. L = lead of spiral for driver = $\pi\, D \cot \alpha$.
8. l = lead of spiral for driven gear = $\pi\, d \cot \beta$.
9. C = actual center distance = sum of pitch radii.

Example

Given or assumed:

1. See illustration. 2. $C_a = 4$ inches. 3. $P_n = 10$.
4 and 5. $\alpha = \beta = 22\frac{1}{2}$ deg. 6. $N = 37$.

To find:

1. $D = \dfrac{N}{0.9239\,P_n} = \dfrac{37}{0.9239 \times 10} = 4.005$ inches.
2. $O = D + \dfrac{2}{P_n} = 4.005 + \dfrac{2}{10} = 4.205$ inches.
3. $T = N \div 0.788 = 37 \div 0.788 = 47$ teeth. (No. 3 cutter).
4. $L = 7.584\,D = 7.584 \times 4.005 = 30.374$ inches.

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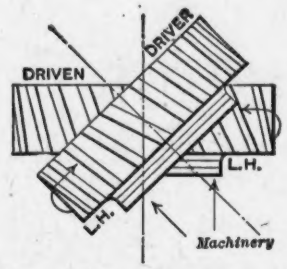
Supplement to MACHINERY, ...
Tables for Article in this number entitled 'Spir...

SPIRAL GEARS WITH SHAFTS AT 45 DEGREES ANGLE—III

Contributed by James H. Carver

Shafts at 45 Degrees Angle, Ratio Unequal, C. D. Approximate



The sum of the spiral angles of the two gears equals 45 degrees, and the gears are of the same hand, if each angle is less than 45 degrees. The difference between the spiral angles equals 45 degrees, and the gears are of opposite hand, if either angle is greater than 45 degrees.

Given or assumed:

1. Hand of spiral, depending on rotation and direction in which thrust is to be received.
2. C_a = center distance.
3. P_n = normal pitch (pitch of cutter).
4. R = ratio of gear to pinion, $N \div n$.
5. α = angle of spiral on gear.
6. β = angle of spiral on pinion.
7. n = number of teeth in pinion nearest $\dfrac{2\,C_a\,P_n \cos\alpha \cos\beta}{R\cos\beta + \cos\alpha}$
8. N = number of teeth in gear = $R\,n$.

To find:

a. When $\alpha = \beta = 22\frac{1}{2}$ degrees.

1. D = pitch diameter of gear = $\dfrac{N}{0.9239\,P_n}$.
2. d = pitch diameter of pinion = $\dfrac{n}{0.9239\,P_n}$.
3. O = outside diameter of gear = $D + \dfrac{2}{P_n}$.
4. o = outside diameter of pinion = $d + \dfrac{2}{P_n}$.
5. T = number of teeth marked on cutter for gear = $N + 0.788$.
6. t = number of teeth marked on cutter for pinion = $n + 0.788$.
7. L = lead of spiral on gear = $7.584\,D$.
8. l = lead of spiral on pinion = $7.584\,d$.
9. C = actual center distance = $\dfrac{D+d}{2}$.

b. When α and β are any angles.

1. D = pitch diameter of gear = $\dfrac{N}{P_n \cos\alpha}$.
2. d = pitch diameter of pinion = $\dfrac{n}{P_n \cos\beta}$.
3. O = outside diameter of gear = $D + \dfrac{2}{P_n}$.
4. o = outside diameter of pinion = $d + \dfrac{2}{P_n}$.
5. T = number of teeth marked on cutter for gear = $N \div \cos^3\alpha$.
6. t = number of teeth marked on cutter for pinion = $n \div \cos^3\beta$.
7. L = lead of spiral on gear = $\pi\,D\cot\alpha$.
8. l = lead of spiral on pinion = $\pi\,d\cot\beta$.
9. C = actual center distance = $\dfrac{D+d}{2}$.

Example

Given or assumed:

1. See illustration. 2. $C = 12$ inches. 3. $P_n = 6$. 4. $R = 3$. 5. $\alpha = 20$ deg. 6. $\beta = 25$ deg.
7. $n = \dfrac{2\,C\,P_n \cos\alpha\cos\beta}{R\cos\beta + \cos\alpha} = \dfrac{2\times 12\times 6\times 0.93969\times 0.90631}{(3\times 0.90631) + 0.93969} = 34$ teeth approximately.
8. $N = Rn = 3\times 34 = 102$ teeth.

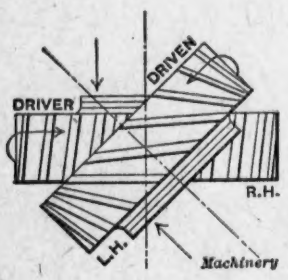
To find:

1. $D = \dfrac{N}{P_n\cos\alpha} = \dfrac{102}{6\times 0.93969} = 18.091$ inches.
2. $d = \dfrac{n}{P_n\cos\beta} = \dfrac{34}{6\times 0.90631} = 6.252$ inches.
3. $O = D + \dfrac{2}{P_n} = 18.091 + \dfrac{2}{6} = 18.424$ inches.
4. $o = d + \dfrac{2}{P_n} = 6.252 + \dfrac{2}{6} = 6.585$ inches.
5. $T = N \div \cos^3\alpha = 102 \div 0.83 = 123$ teeth.
6. $t = n \div \cos^3\beta = 34 \div 0.744 = 46$ teeth.
7. $L = \pi\,D\cot\alpha = \pi\times 18.091\times 2.747 = 156.12$ inches.
8. $l = \pi\,d\cot\beta = \pi\times 6.252\times 2.145 = 42.13$ inches.
9. $C = \dfrac{D+d}{2} = \dfrac{18.091 + 6.252}{2} = 12.1715$ inches.

SPIRAL GEARS WITH SHAFTS AT 45 DEGREES ANGLE—IV

Contributed by James H. Carver

Shafts at 45 Degrees Angle, Ratio Unequal, Center Distance Exact



The sum of the spiral angles of the two gears equals 45 degrees, and the gears are of the same hand, if each angle is less than 45 degrees. The difference between the spiral angles equals 45 degrees, and the gears are of opposite hand, if either angle is greater than 45 degrees.

Given or assumed:

1. Hand of spiral, depending on rotation and direction in which thrust is to be received.
2. P_n = normal pitch (pitch of cutter).
3. R = ratio of large to small gear = $N \div n$.
4. α_a = approximate spiral angle of large gear.
5. β_a = approximate spiral angle of small gear.
6. C = center distance.
7. n = number of teeth in small gear nearest $\dfrac{2\,C\,P_n\cos\alpha_a\cos\beta_a}{R\cos\beta_a + \cos\alpha_a}$.
8. N = number of teeth in large gear = $R\,n$.

To find:

1. α and β, exact spiral angles, by trial from $R\sec\alpha + \sec\beta = \dfrac{2\,C\,P_n}{n}$.
2. D = pitch diameter of large gear = $\dfrac{N}{P_n\cos\alpha}$.
3. d = pitch diameter of small gear = $\dfrac{n}{P_n\cos\beta}$.
4. O = outside diameter of large gear = $D + \dfrac{2}{P_n}$.
5. o = outside diameter of small gear = $d + \dfrac{2}{P_n}$.
6. T = number of teeth marked on cutter for large gear = $N \div \cos^3\alpha$.
7. t = number of teeth marked on cutter for small gear = $n \div \cos^3\beta$.
8. L = lead of spiral for large gear = $\pi\,D\cot\alpha$.
9. l = lead of spiral for small gear = $\pi\,d\cot\beta$.

Example

Given or assumed:

1. See illustration. 2. $P_n = 4$. 3. $R = 4$.
4. $\alpha_a = 50$ degrees. 5. $\beta_a = 5$ degrees. 6. $C = 30$ inches.
7. $n = \dfrac{2\,C\,P_n\cos\alpha_a\cos\beta_a}{R\cos\beta_a + \cos\alpha_a} = \dfrac{2\times 30\times 4\times 0.643\times 0.996}{(4\times 0.996) + 0.643} = 33$ teeth.
8. $N = Rn = 4\times 33 = 132$ teeth.

To find:

1. α and β from $R\sec\alpha + \sec\beta = \dfrac{2\,C\,P_n}{n} = \dfrac{2\times 30\times 4}{33} = 7.273$. By trial $\alpha = 50°\,21'$, and $\beta = 5°\,21'$.
2. $D = \dfrac{N}{P_n\cos\alpha} = \dfrac{132}{4\times 0.63810} = 51.716$ inches.
3. $d = \dfrac{n}{P_n\cos\beta} = \dfrac{33}{4\times 0.99564} = 8.286$ inches.
4. $O = D + \dfrac{2}{P_n} = 51.716 + \dfrac{2}{4} = 52.216$ inches.
5. $o = d + \dfrac{2}{P_n} = 8.286 + \dfrac{2}{4} = 8.786$ inches.
6. $T = N \div \cos^3\alpha = 132 \div 0.26 = 508$ teeth.
7. $t = n \div \cos^3\beta = 33 \div 0.987 = 33$ teeth.
8. $L = \pi\,D\cot\alpha = \pi\times 51.716\times 0.82874 = 134.6$ inches.
9. $l = \pi\,d\cot\beta = \pi\times 8.286\times 10.678 = 278$ inches.